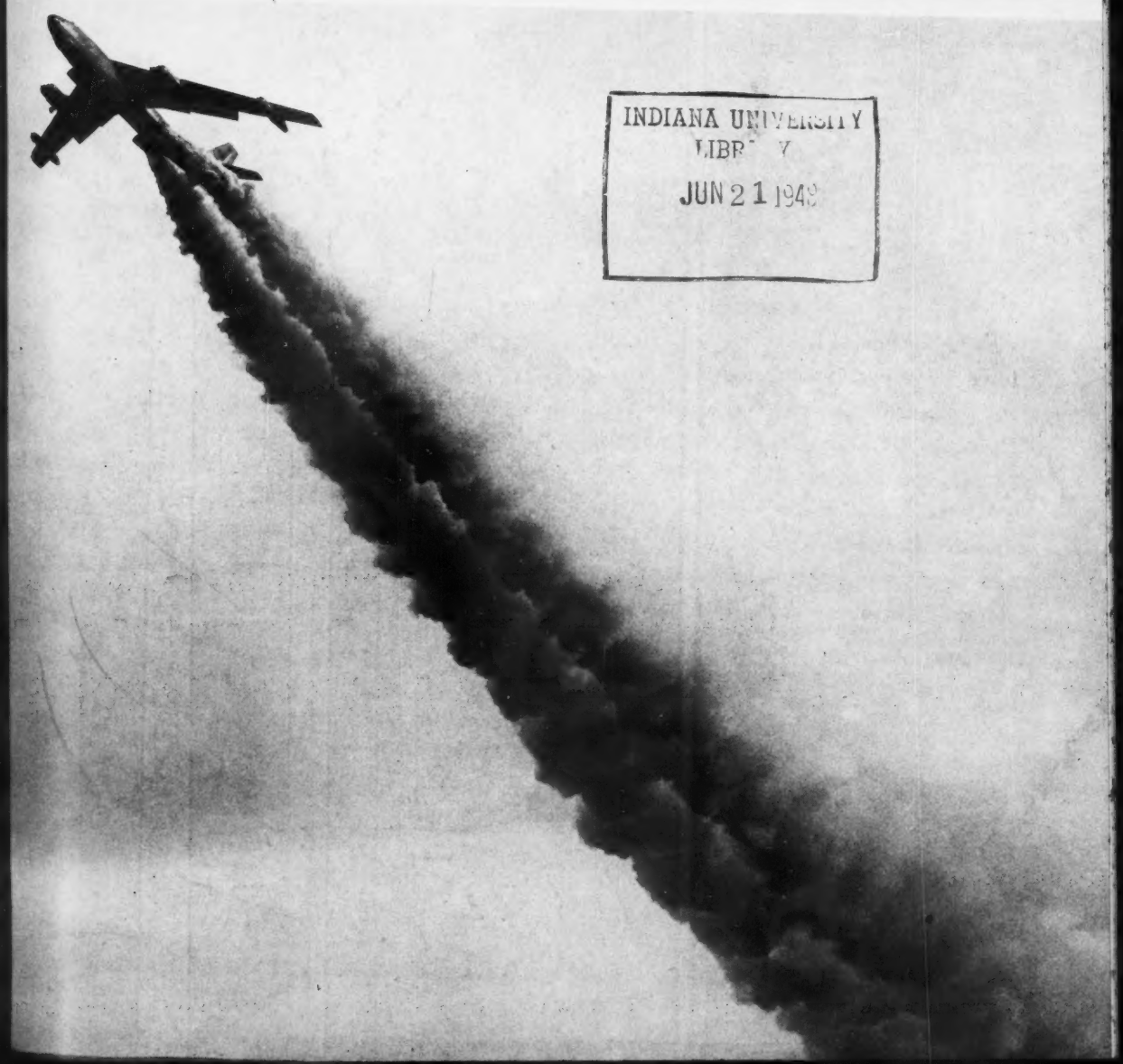
AERONAUTICAL ENGINEERING REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

JUNE 1948



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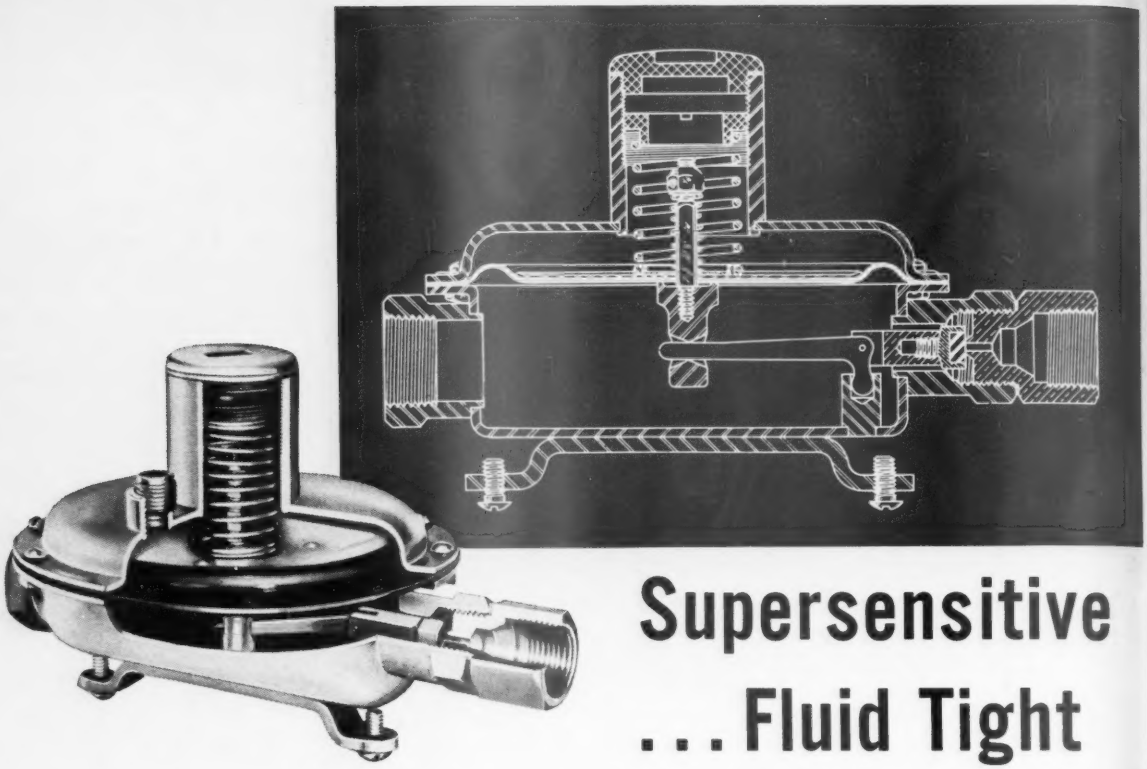

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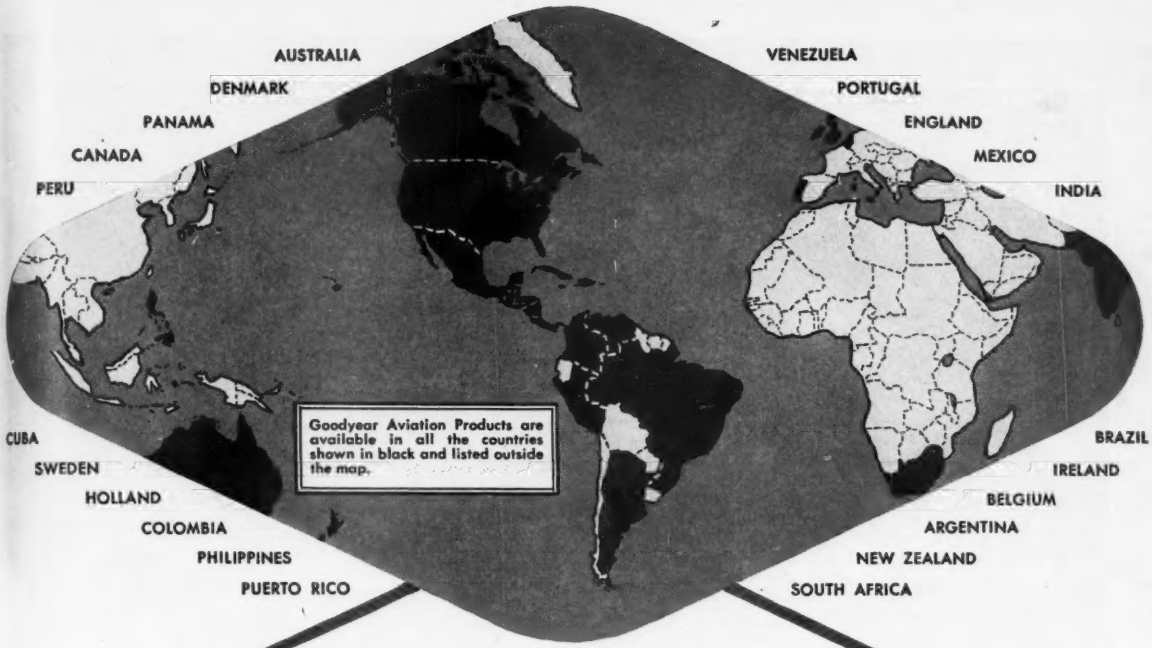

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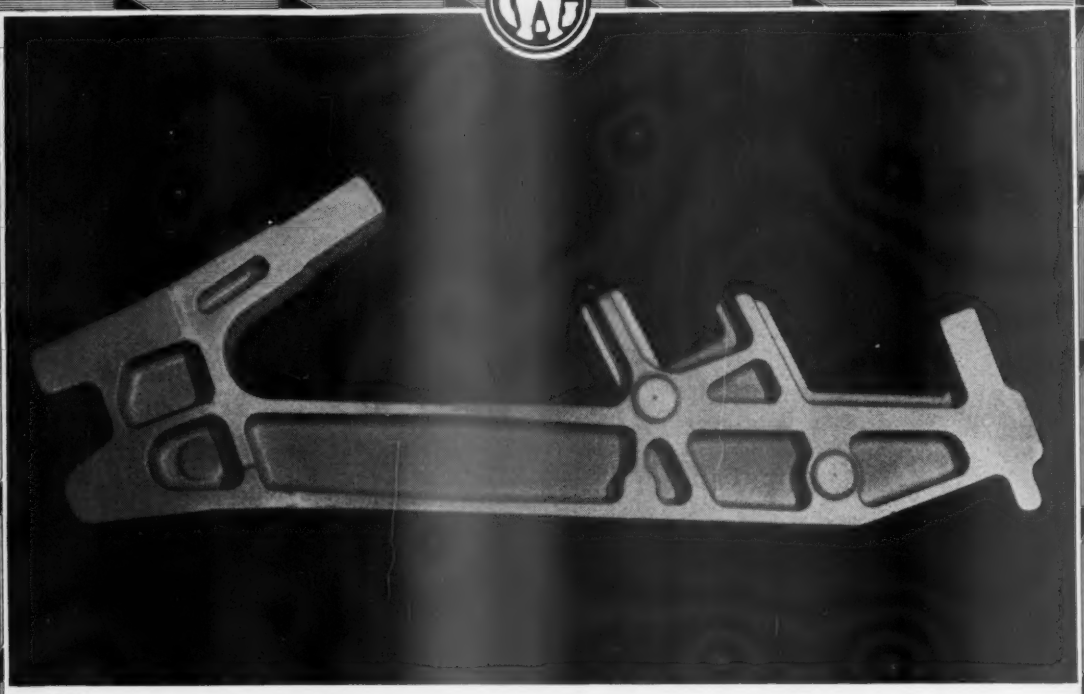

THE forging shown above, over six feet in length, is used in the fuselage structure of one of the fastest aeroplanes in the world. It is forged from 75-S aluminum alloy and is one of the largest die forgings ever attempted in this difficult material. The availability of such forgings opens new opportunities for aircraft builders to simplify and improve many structures which heretofore of necessity have been built-up assemblies—all of which will promote increased quality and performance, together with decreased costs, and thus further enhance the superiority of American aircraft design.

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Cover—Boeing XB-47 Stratojet.

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AERONAUTICAL ENGINEERING REVIEW

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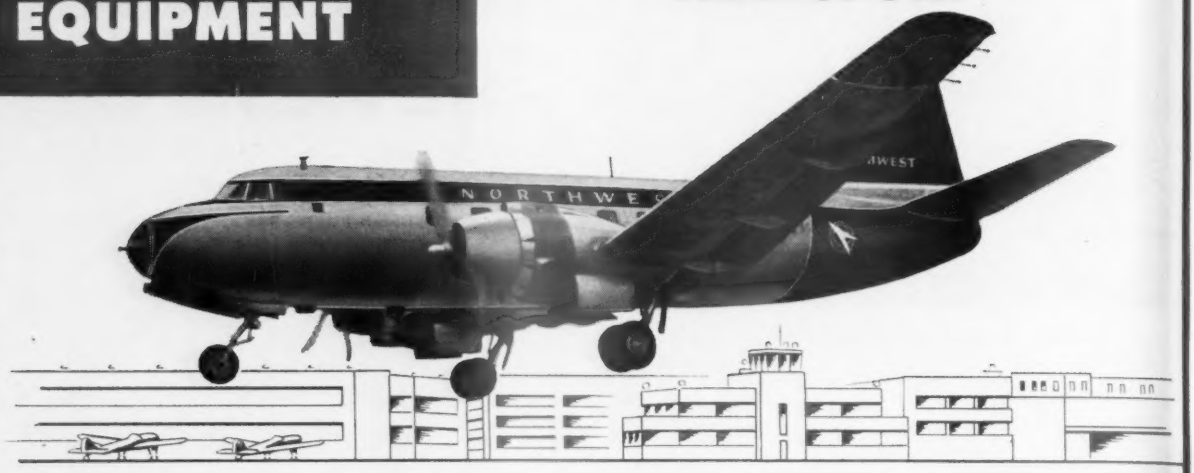
VICKERS 3000 psi HYDRAULIC EQUIPMENT *for* COMMERCIAL AIR TRANSPORT



NORTHWEST AIRLINES' MARTIN 202'S

One of the first postwar designs in commercial operation . . . Northwest Airlines' Martin 202's . . . makes extensive use of Vickers Hydraulic Equipment.

To meet the exacting requirements of this new air transport, Vickers perfected a "dual pressure" hydraulic system having a single power source and requiring minimum weight per horsepower. The 3000 psi system is subject to intermittently high power requirements such as landing gear and flap actuation. The 1500 psi system meets the more or less continual demands which exist both during flight and while on the ground. Typical of this duty are windshield wipers, brakes, nose wheel steering and loading ramp operation.

The 3000 psi system is of the "open center type" which permits free flow of oil back to reservoir at negligible pressure when no power is required.

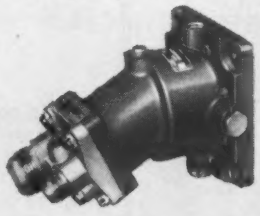
The 1500 psi system is of the "closed center type" incorporating an accumulator. The accumulator provides for the storage of an adequate supply of oil under pressure to meet normal operating requirements. Thus the pump runs unloaded except when demands upon the system exceed the capacity of the accumulator.

As both the 3000 psi and 1500 psi systems have a common power source, a pressure reducing valve is placed between the unloading valve and the accumulator in the 1500 psi system, to insure against overload in the accumulator.

These important features are but a few of the many advantages offered by Vickers Hydraulic Equipment which is helping Northwest Airlines and their 202's achieve a new measure of operational efficiency. For more detailed information, write for Bulletin 46-41.

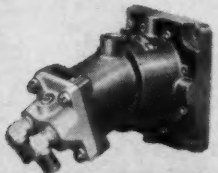
Vickers 3000 psi Reducing-Relief Valve

Vickers 3000 psi Unloading Valve

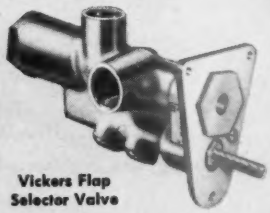


Vickers 3000 psi Constant Displacement Piston Type Pump

Vickers Landing Gear Selector Valve



Vickers 3000 psi Constant Displacement Piston Type Motor



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I.A.S. News

A Record of People and Events of Interest to Institute Members

Annual Summer Meeting Program Plans Under Way

Sixteenth Anniversary Dinner, Pilots Symposium Scheduled for July 14–16, Meeting in Los Angeles; Pt. Mugu Naval Air Missile Center Tour Planned.

TWO DAYS OF TECHNICAL SESSIONS, including a Pilots Symposium, in addition to a tour of the U.S. Naval Air Missile Test Center at Pt. Mugu, Calif., and the Institute's Sixteenth Anniversary Dinner, have been planned by the Annual Summer Meeting Program Committee under chairmanship of J. E. "Joe" Barfoot, Strength & Test Superintendent of Douglas Aircraft Company, Inc. (El Segundo).

Chairman and host for the I.A.S. Summer Meeting at the Hotel Ambassador in Los Angeles will be Willis M. Hawkins, Jr., Los Angeles Section Chairman and Chief Preliminary Design Engineer, Lockheed Aircraft Corporation. Dates for the meeting, including the Pt. Mugu trip and Dinner, are July 14–16.

▸ **Test Pilots Symposium**—Five "hot" test pilots will participate in a Symposium in the Ambassador's Rose Room at 8:00 p.m., July 16. In addition, Dr. C. F. Lombard, University of Southern California, will give a prepared comment on aeromedical aspects, and W. C. Rockefeller, Alvin P. Adams & Associates, will speak from the engineering point of view.

J. E. Barfoot, Program Chairman of Annual Summer Meeting.

As this issue goes to press, the Symposium has been scheduled as a closed session.

Pilots and papers include:

- "Joe" Towle, Lockheed Flight Test Department—"Crew Escape Methods and Ditching of Large Aircraft."
- Russell W. Thaw, Engineering Test Pilot, Douglas—"Crew Escape Methods in Small Aircraft."
- "Gene" May, Douglas (El Segundo) Flight Test Department—"Problems of Flight at High Altitude."
- Marvin Michael, Boeing Flight Test Department—"Combat Aircraft Cockpits."
- Robert Chilton, Chief Test Pilot, North American—"Maneuverability of Fighters and Bombers at High Altitude."

Colonel C. A. Schoop, Commanding Officer, 146th Fighter Group, California National Guard, will chairman the Symposium.

On July 15, Structures will be the opening session, Dr. E. E. Sechler, Caltech, Chairman. The three papers include: "Principles of Structural Design for Minimum Weight"—F. R. Shanley, Consultant; "Shear Stress Concentration and Moment Reduction Factors for Reinforced Monocoque Cylinders Subjected to Concentrated Radial Loads"—N. J. Hoff, Brooklyn Polytech; "Application of Simultaneous Equation Machines to Aircraft Structure and Flutter Problems"—P. A. Dennis and D. G. Dill, Douglas.

Willis M. Hawkins, Jr., Chairman, Los Angeles Section.

Aircraft Design, the afternoon session, with Chairman Frank Fink, Chief Engineer, Convair, presiding, will include: "Factors Influencing the Design of Carrier-Based Aircraft"—Rear Adm. F. C. Lonnquest, BuAer; "Servo Systems for Aircraft"—John Moore, North American Aviation, and "Application of Metallurgy to Aircraft Design"—L. Schapiro, Douglas (Santa Monica).

▸ **Other Sessions**—Opening session on July 16 will be on Flight Propulsion with R. P. Kroon, Engineering Manager, Westinghouse Electric, as Chairman. Papers will include: "Testing Jet Engines Under Simulated Airspeed and Altitude Conditions"—Dr. J. F. Manildi, Director of Research, G. M. Giannini & Company, Inc., and Assistant Professor, University of California, Los Angeles; "Jet Pro-

pulsion in Commercial Air Transportation"—Robert Hage, Boeing.

The afternoon session, Aerodynamics and Hydrodynamics, following the Luncheon will be chairmanned by Capt. W. S. Diehl, Navy BuAer. Papers and authors are: "Aerolastic Effects on Swept Wings"—W. R. Sears, Cornell; "Recent N.A.C.A. Research on High-Length Beam Ratio Hulls"—A. W. Carter, Langley Memorial Aeronautical Laboratory; "Design and Operation of a 12-Inch Supersonic Tunnel"—A. E. Puckett, Caltech; "Flight and Tunnel Test Research on Boundary Layer Control"—H. B. Dickinson, Lockheed.

▶ **Bane, Chanute Awards**—Two Institute awards will be made on the occasion of the Sixteenth Annual Dinner—The Thurman H. Bane Award and The Octave Chanute Award. Presentation of the former will be made to an officer or civilian of Air Materiel Command for an outstanding achievement in aeronautical development during the year, while the Chanute Award will go to a pilot for a notable contribution to the aeronautical sciences.

Set Tentative Date for Joint I.A.S.-R.Ae.S. Meeting

GROUNDWORK FOR THE RETURN ENGAGEMENT of the joint Institute and Royal Aeronautical Society meeting has been begun by appointment of an Arrangements Committee and a Program Committee by President John K. Northrop. A tentative date of April, 1949, has been selected for what is expected to be one of the most important events on the Institute's calendar.

▶ **High Standard Set in London**—The great success of the first joint meeting in London last September was due not only to the excellence of the technical papers presented by both British and American aeronautical experts but to the well-conceived and adroitly executed schedules of our British hosts leavened by a smooth flow of hospitality that characterized the entire visit. The standard set for us in England will require every effort on the part of the I.A.S. membership in order that we may reciprocate in kind.

The Institute's international meetings provide the most practical means for technical collaboration.

Any suggestions, ideas for papers, procedures, and programs will be welcomed by the officers of the Institute.

▶ **Committees Chosen**—President Jack Northrop in the meantime has selected the following members of the Arrangements Committee: Chairman, Preston R. Bassett; committee members, Hugh L. Dryden, Sherman M. Fairchild, Charles H. Colvin, E. D. Osborn, Rex B. Beisel, L. B. Richardson, W. A. M. Burden, Burdette Wright, A. D. Emil, Leroy R. Grumman, Glenn L. Martin, William R. Enyart, Mundy I. Peale, and John J. Ide.

Chairman of the Program Committee is T. P. Wright, and Vice-Chairman is R. G. Robinson. Committee members are: C. B. Millikan (Aerodynamics), Abe Silverstein (Flight Propulsion), N. J. Hoff (Structures), R. W. Young (Power Plants), E. G. Stout (Hydrodynamics and Flight Testing), A. E. Raymond (Design and Air Transport), and I. I. Sikorsky (Rotating Wing).

Although certain economic obstacles remain to be overcome, the Second Joint Conference of the Institute and Royal Aeronautical Society is expected to be as successful both technically and in execution as the memorable first meeting in London.

Goddard Rocket Exhibit Opened in New York

The Robert H. Goddard Rocket Exhibit, built under the auspices of The Daniel and Florence Guggenheim Foundation, was opened in New York April 21. Principal speakers were James H. Doolittle, Vice-President of Shell Union Oil Corporation and an Honorary Fellow of the Institute, and Harry F. Guggenheim, President of the Foundation, an I.A.S. Honorary Member.

▶ **"Father of Modern Rockets"**—Speaking at the preview of the exhibit, which contains the original rockets and apparatus developed by Dr. Goddard, at the American Museum of Natural History, Mr. Guggenheim called the rocket scientist the "father of modern rockets" just as surely "as the Wright brothers were of the airplane."

Today his accomplishments in rocket development constitute the foundation of the science and the fast-growing industry devoted to rockets and jet propulsion.

Dr. Goddard died August 10, 1945, while on a wartime rocket research assignment for the U.S. Navy.

The world first heard of Dr. Goddard on July 17, 1929, when, with a small group of associates, he launched a liquid fuel rocket near Worcester,

At Opening of Robert H. Goddard Rocket Exhibit in New York (*left to right*): *J. H. Doolittle, formerly Lieutenant General of the Air Forces and now Vice-President of Shell Union Oil Corporation, who spoke; Dr. Albert E. Parr, Director of The American Museum of Natural History where the exhibit was built and first shown; Mrs. Robert H. Goddard, wife of the late Dr. Goddard, the American rocket and jet propulsion pioneer; Harry F. Guggenheim, President of The Daniel and Florence Guggenheim Foundation, which supported much of Dr. Goddard's work and which sponsors the Exhibit; Mrs. Roger W. Strauss, Vice-President of The Foundation; and Col. Charles A. Lindbergh.*

Mass. Carrying a barometer and thermometer and a small camera to photograph these instruments, it was the world's first instrument-carrying rocket.

▸ **Lindbergh Tells of Test**—Charles A. Lindbergh, an I.A.S. Fellow, who was a trustee of the Guggenheim Aeronautical Foundation, told Daniel Guggenheim of Goddard's experiment, and an arrangement was made whereby Dr. Goddard was enabled to carry on his work under adequate conditions at a testing ground near Roswell, N.M.

▸ **Doolittle Lists "Firsts"**—In an address in which he said he was "certain that out of our scientific endeavor will come new weapons . . . which will assure our ability to defend ourselves and to help maintain a decent peace," General Doolittle listed a number of "firsts" in rocket research, "any one of which would be sufficient to assure him" (Dr. Goddard) "a permanent place in the history of modern science and engineering." Among the principal ones were:

- **Development of basic idea** of the bazooka in 1918 during World War I. The weapon was not used until World War II.
- **Development of rocket motor** using liquid fuels; used it in a liquid fuel propelled rocket in 1926, nearly 18 years before the Germans fired their V-2.
- **Dr. Goddard was first** to shoot a rocket faster than speed of sound.
- **He developed a gyroscopic** steering apparatus for rockets 10 years before the Germans did.
- **He was first to use vanes** in the rocket motor blast for steering purposes.
- **He patented** the idea of "step-rockets."
- **Developed the mathematical** theory of rocket propulsion and rocket flight on which all modern military and experimental calculations are based.
- **First proved,** both mathematically and by actual test, that a rocket will work in a vacuum; that it needs no air or other substance to push against.

The Daniel and Florence Guggenheim Foundation, according to Harry F. Guggenheim, will continue to sponsor the development of the peacetime application of jet propulsion and the rocket.

Weick, Ercoupe Designer, Goes to Texas A. & M.

Designer of the two-control Ercoupe, Fred E. Weick, an I.A.S. Fellow, has announced his resignation as Vice-President, Engineering, Engineering & Research Corporation, to accept a post as Aeronautical Professor and Research Engineer at Texas A. & M. College, Bryan, Tex.

Fred E. Weick.

▸ **Top Light-Plane Authority**—Recognized as a top authority on light-plane design in this country, Mr. Weick had been with Engineering & Research Corporation for more than 11 years. He will be retained by the company as a Consultant on aircraft development.

In the early '30's, he was top engineer and aerodynamicist at N.A.-C.A.'s Langley Field, Va., lab. where he first developed in spare time the revolutionary W-1, a twin-boom, two-control plane. The Ercoupe was a production model of this plane.

Heat Transfer and Fluid Flow Meetings Scheduled in June

An Institute on Heat Transfer and Fluid Mechanics is scheduled for June 21, 22, 23, to be held for one day each on campuses of the University of California, Los Angeles; University of Southern California; and the California Institute of Technology.

Papers on the basic nature of heat transmission and fluid flow will be presented in the program. Heat transfer at sub- and supersonic speeds, boiling of liquids, heat transfer in porous metals, dynamics of cavitation, fluid flow at low pressures, and stability of the boundary layer with and without gas injection are among the subjects to be considered.

Sponsored by the California sections of the A.S.M.E., I.A.S., and other scientific societies, the Institute's General Chairman is Prof. Robert T. Knapp, Director, Hydrodynamics Laboratory, Cal-Tech. Professor L. M. K. Boelter, Dean, College of Engineering, University of California, is Chairman of the Papers Committee; and J. C. Dillon, University of California, is Chairman of the Program Committee.

National Meeting Calendar

July 14–16	Annual Summer Meeting, Los Angeles
December 17	Wright Brothers Lecture, Washington, D.C.
January 24–27	Seventeenth Annual Meeting, New York

For details see page 92.

University of Wisconsin Holds Symposium Sept. 7–11, 1948

The Third Symposium on Combustion and Flame and Explosion Phenomena will be held by the University of Wisconsin, Madison, September 7 through 11, 1948. An open invitation is extended to all interested.

For details regarding accommodations, procedures, and papers, contact either Dr. Bernard Lewis, Bureau of Mines, 4800 Forbes St., Pittsburgh 13, Pa., or Dr. J. O. Hirschfelder, Department of Chemistry, University of Wisconsin, Madison 6.

L'Aerotecnica Available to U.S. Subscribers

The Italian aeronautical periodical *L'Aerotecnica*, containing original papers contributed by Italian scientists and engineers on theoretical and applied research, summaries on the present situation of important aeronautical problems, and reviews of aeronautical literature, both Italian and foreign, is again available to prospective subscribers in this country.

Publication office is Piazza S. Bernardo, 101, Rome, Italy; Editorial office, Scuola d'Ingegneria, Pisa.

Atlas Sky Merchant Completes 44,500-Mile Trip

Atlas Supply Company's DC-4, Atlas Sky Merchant, which completed a round-the-world trip of 44,500 miles, returned to New York with its crew of seven and ten businessmen. Among the latter was E. E. Aldrin, I.A.S. Fellow and member of the Council, who is Aviation Director of the company.

The Sky Merchant, which is specially fitted to contain a streamlined display of Atlas Supply Com-

pany merchandise, toured the U.S., Canada, and South America before completing its round-the-world flight.

Elect Admiral Richardson President of Fairchild

The Board of Directors of Fairchild Engine & Airplane Corporation has named Rear Adm. Lawrence B. Richardson, U.S.-N. (Ret.), the corporation's new President replacing J. Carlton Ward, Jr., President of Fairchild since 1940. Mr. Ward, an I.A.S. Member, was elected Chairman of the Board of Directors, in which post he will act as the Chief Executive Officer. He will continue to head the NEPA project for development of means whereby nuclear energy may be applied to aircraft propulsion.

▶ **Was V.-P., Curtiss-Wright**—Admiral Richardson, an I.A.S. Fellow and member of the Council and Advisory Committee, resigned as Vice-President and Executive Assistant to the President of the Curtiss-Wright Corporation early in March. He had been with Curtiss-Wright 1 year and 5 months.

Navy member of the National Advisory Committee for Aeronautics and of the Joint Army-Navy Aircraft Committee, later known as the Aeronautical Board, before his retirement from the Navy in August, 1946, Admiral Richardson has a broad background of experience in aviation including design, development, manufacture, and inspection.

He is a member of Cornell Research Foundation's Board of Directors at Cornell University and the visiting committee of the Department of Aeronautical Sciences at M.I.T.

Gifts to the Aeronautical Collections

John Walter Wood gave six file drawers of plans, photographs, pamphlets, and other descriptive material on the major airports of Europe and the United States, comprising one of the most complete collections on airports available for study. Richard T. Crane sent a 33-in. model of the Martin "China Clipper." W. A. M. Burden added foreign air-line reports of the 1930's and 98 issues of periodicals to his previous generous gifts. The official program of the aviation meet held in Los Angeles in January, 1910, was received from O. S. Watts, of Tarzana, Calif.

The Curtiss-Wright Corporation, Propeller Division, sent over 1,000 issues of technical periodicals. Issues of the Palestine journal, *Technics and Science*, for 1947 were received from Dr. Fidia J. Piatelli.

Airplane maintenance manuals were received from the Lockheed Aircraft Corporation and Northrop Aircraft, Inc. Its library catalog was received from the Aéro-Club de France. Monographs and summaries of reports on compressible flow were given by the Graduate Division of Applied Mathematics of Brown University. Two issues of *Isis* for May, 1947, containing an article on "The Development of Aeronautics in America," were received from the History of Science Society through the courtesy of Alexander Pogo. Additions to their previous generous gifts were given by Dr. Otto Kallir, Dr. Alexander Klemin, and Mrs. Bella C. Landauer.

Additional gifts were received from The Asphalt Institute; Boeing Airplane Company; David Taylor Model Basin of the U.S. Navy Department; Naval Medical Research Institute of Bethesda, Md.; Office of Naval Research, Special Devices Center; Manufacturers Aircraft Association; and Joseph A. Rice, of Troy, N.Y.

I.A.S. Newslines

▶ Passenger service with the new Convair Liner, 75 of which have been ordered by American Airlines, is expected to start this month, according to **Ralph S. Damon,** President, a Fellow. He believes air cargo will double every year until there is a business depression, and even then may pay off. . . .

▶ Presidential interrogation. . . . **Donald W. Douglas,** Honorary Fellow and Past-President (1935) of the Institute, conferred with President Truman late in March, reportedly answering numerous queries about the aircraft industry's ability to expand in event of emergency. Mr. Douglas has been elected board member of National Industrial Conference Board for forthcoming year.

▶ World's first long-range jet air force . . . Speaking of new jet engine developed by Lockheed and to be produced by Wright Aeronautical at Wood-Ridge, **Hall L. Hibbard,** Fellow and Advisory Council member, said: "The efficient fuel consumption, combined with its tremendous power,

I.A.S. Director on Temporary Active Duty: *Four of the Navy and Air Force Reserve officers who served on temporary tours of active duty as staff assistants to the Navy-Air Force working group that drew up the plans for the Military Air Transport Service are shown with Major Gen. Laurence S. Kuter, Comdr., MATS, and Rear Adm. John P. Whitney, Vice Comdr. Left to right are: Capt. S. Paul Johnston, U.S.N.R.; Col. Henry C. Kristoffer-son, U.S.A.F. (Res.); Admiral Whitney; General Kuter; Capt. Paul Richter, U.S.N.R. and Col. G. Grant Mason, U.S.A.F. (Res.). The fifth member of the Reserve staff, Col. Samuel E. Gates, U.S.A.F. (Res.) is not shown.*

will make possible the world's first long-range jet air force with bombers and fighters capable of flying extended missions greater than those of today's fastest airplanes."

▸ Professor Emeritus of M.I.T., and Fellow of I.A.S., **William Hovgaard,** 90, received the Gold Medal of the American-Scandinavian Foundation for services to America and Scandinavia.

▸ Most vital objective facing aviation today is the implementation of the all-weather flying program, **Vice Adm. Emory S. Land,** a Fellow, told delegates to the California Aviation Conference. Admiral Land, President, Air Transportation Association, was recently made an Honorary Knight Commander of the Military Division of the Order of the British Empire in a ceremony at the British Embassy.

▸ The Flight Safety Foundation, nonprofit organization dedicated to greater safety through scientific study, experimentation, education, and services in the fields of design, equipment, and practice, has elected **Jerome Lederer,** I.A.S. Fellow, its President.

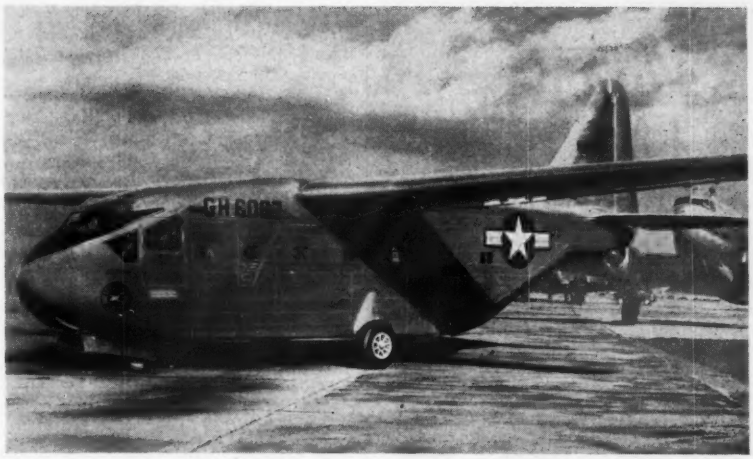
▸ Retirement of **Gen. Carl Spaatz,** Air Force Chief of Staff and former commander of the greatest aggregation of air power ever in use in the world, was announced by the White House April 1. Succeeding General Spaatz, an Honorary Member, is Gen. Hoyt S. Vandenburg.

▸ Iron curtain in Arctic? . . . Russia is building up an air force opposite Alaska which may be superior to that under his command, reports **Lt. Gen. Nathan F. Twining,** Honorary Member, and commanding general of combined Army, Navy, and Air Force units in Alaskan Territory. General Twining has announced formation of a Territorial Guard in Alaska composed of 1,000 Indians and Eskimos. Versed in Arctic lore, they will be under control of Governor Ernest Gruening.

Chase Aircraft Company Joins Institute

New Corporate Member of the Institute is Chase Aircraft Company, Inc., which recently celebrated its fifth birthday. Activities of the company during this time have been devoted to the design, development, and production of experimental assault cargo aircraft for the Air Force.

▸ **Three Aircraft Built**—Under leadership of Michael Stroukoff, founder and Chief Engineer, Chase Aircraft designed and produced three cargo-type planes. First of these was the XCG-14, a 16-passenger troop-carrying glider of all wood construction which was flown in January, 1945.



Riding the Stroukoff Wing: *The CG-18A "Avitruc" all-metal glider built for the Air Force by Chase Aircraft Company, Trenton, N.J., a new I.A.S. Corporate Member. Aerodynamic characteristics of the wing section, developed by Michael Stroukoff, President and Chief Engineer, are described as being superior to those of any other known airfoil. An extremely thin section, it is somewhat similar to the NACA 23,000 series.*

Next came the XCG-14A, a 24-place troop and cargo glider, also of wood construction. The 14A first flew in October, 1945.

During late 1946, the company converted to all-metal design and production and moved from New York to its present location at Mercer County Airport, Trenton, N.J. In a little more than a year the all-metal 32-place XCG-18A cargo and troop transport was designed, built, and flown.

Executive and technical personnel at Chase Aircraft include: M. Stroukoff, President and Chief Engineer; John F. Ryan, Vice-President and Purchasing Agent; William F. Sauers, Secretary and Executive Engineer; Jesse X. Cousins, Treasurer and Comptroller; Michael Gregor, Assistant Chief Engineer; Lewis J. Stowe, Project Engineer; George G. Cudhea, Project Engineer; and John Gitz, Production Engineer.

Corporate Member News

• Guided missiles course for a select group of officers of U.S. Ground Forces, Navy Canada, and Great Britain, is being given by **Aerojet Engineering Corporation.** Course includes numerous field trips to rocket and missile installations in Southern California area in addition to 19 lectures.

• Olympic games steps up flights . . . Reporting a heavy advanced booking, **American Overseas Airlines, Inc.,** announced an increase in its transatlantic schedules, effective May 1, because of the Olympic games . . . American's European executive offices in Britain have been moved to 15 Hill St., Berkeley Sq., London, W.1.

• With reopening of the flight hangar and an adjacent building of the Wichita plant of **Boeing Airplane Company** for modernization of B-29 Superforts, company is hiring 1,000 skilled men for specialized labor to start new program.

• In the black . . . **Beech Aircraft Corporation** had an unaudited net income of $676,480 after provision for taxes in 6-month period ended March 31 of its current fiscal year, Walter H. Beech, President and Chairman, announced.

• Quitting Stratford, Conn., site for Dallas . . . Beginning early last month, the **Chance Vought Division,** United Aircraft Corporation, builders of Navy jet fighters, started its transfer to the big, Government-owned Navy stand-by plant at Dallas, Tex. Move will require about a year to complete and is in line with national defense policy to disperse plants vital to national security into less concentrated manufacturing areas.

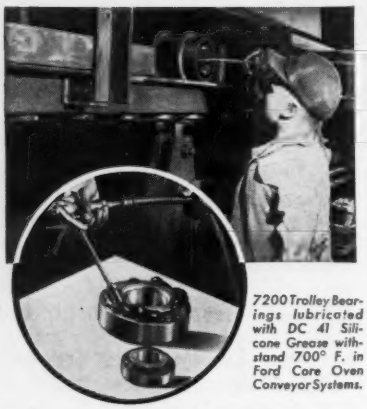
• Could have stayed up longer . . . Shuttling between Ft. Worth and the West Coast, a B-36 landed after more than 30 hours in the air, completing longest test flight a plane of its size has made, **Consolidated Vultee Aircraft Corporation** announced. Officials added the B-36 could have stayed up longer.

• Major overhaul . . . **Douglas Aircraft Company, Inc.,** is putting all Eastern Air Lines DC-4's through major overhaul at Santa Monica in a program covering several months' period beginning last April.

Silicone News

DC SILICONES

Ford Uses Silicone Grease in Bearings at 700° F.



7200 Trolley Bearings lubricated with DC 41 Silicone Grease withstand 700° F. in Ford Core Oven Conveyor Systems.

PHOTO COURTESY FORD MOTOR COMPANY

The cost of designing around the thermal limitations of organic greases is often prohibitive. In such cases, frequent relubrication, high maintenance costs, and production stoppages were inevitable until Dow Corning introduced a line of semi-inorganic silicone greases serviceable at temperatures far above the limits of organic greases.

The economy of this new solution to high temperature lubrication problems is demonstrated in the core oven conveyor systems operated by the Ford Motor Company. These core ovens operate 16 hours a day, 5 days a week, at a peak heat of 700° F. The 7200 trolley bearings are exposed to such temperatures for 2½ hours out of every 4 hours. Even with automatic oiling, the bearings froze, wheels were flattened, and production was interrupted.

After careful testing, Ford's Chemical Engineering Department recommended DC 41 Silicone Grease. Lubricated with this heat-stable silicone grease, the conveyor systems require considerably less power to operate. They start easily and run continuously. Replacement and maintenance costs are greatly reduced and the bearings exposed to 700° F. are relubricated only once a week.

If you have a high temperature or permanent lubrication problem, write for Dow Corning Silicone Grease data sheet No. S 7-2 or call our nearest branch office.

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Dow Corning
FIRST IN SILICONES

• At record high . . . Revenues of **Eastern Air Lines, Inc.,** last year reached $52,411,248, highest in its history, exceeding 1946 total by 24.4 per cent. Expenses, however, rose from $33,844,074 in 1946 to $49,642,052, largely due to labor costs and materials and provision for depreciating new-type Connies over a 4-year period.

• Air Force has announced that work on jet-propelled helicopters will be carried out at **General Electric Company's** flight-test center near Schenectady.

• America's first jet trainer, a new two-seater type modeled after the Lockheed P-80 Shooting Star, designed and built by **Lockheed Aircraft Corporation,** successfully completed preliminary flight tests. New jet trainer is powered by Allison Model 400 engine and is designated TF-80C.

• Two thousand engineers of **The Glenn L. Martin Company** are working on guided-missile projects and on "other advanced research," Glenn L. Martin, pioneer aircraft designer said at a press conference.

• AT-6 trainer modification line will be moved from **North American Aviation, Inc.,** Los Angeles plant, to former Convair plant at Downey, Calif., where North American has leased 600,000 sq.ft.

• Something to chew on . . . **Pan American World Airways System** Clippers recently delivered two loads of bubble gum to Venezuela.

• Approximately 2,700 personal planes were sold during 1947 by **Stinson Division,** Consolidated Vultee Aircraft Corporation. Stinson was one of companies to make a profit on personal planes in the past year.

• In the face of the worst winter weather in air-line history, Constellations of **Trans-continental & Western Air, Inc.** (Trans World Airlines) carried 117,000 passengers on domestic routes, completing 97 per cent of scheduled mileage for the period November 1–March 15.

• Contrary to trend . . . **United Aircraft Corporation** realized a net profit of $9,816,295 on sales of $208,263,495, company's annual report revealed.

• An all-Wright design . . . Successful completion of initial flight tests of a new gas turbine, the T-35 Typhoon, was announced by **Wright Aeronautical Corporation Division,** Curtiss-Wright Corporation, in April. Under secret development for several years, it is an all-Wright design of which performance, power output, and type details are still restricted.

Meet Your Section Chairman

Cleveland Section

Abe Silverstein

A native of the Hoosier State, where he was born in Terre Haute in 1908, Abe Silverstein has been with the National Advisory Committee for Aeronautics since he was graduated from Rose Polytechnic Institute with a B.S. in Mechanical Engineering, June, 1929. He received his M.E. degree from the same school in 1934.

▶ **Took Leading Part**—Starting at the Langley Memorial Aeronautical Laboratory, Hampton, Va., Mr. Silverstein suggested and took a leading part in a number of important research programs. He was head of the Full-Scale Wind Tunnel Section from 1940–1943, with responsibility for directing the work toward improving high speeds of military aircraft.

In 1943 he left Langley to become Chief of the Engine Installation Research Division at the N.A.C.A. Cleveland Flight Propulsion Research Laboratory. There, during the war, he conducted research in the Cleveland altitude wind tunnel on:

• **Cooling** of reciprocating engines.

• **Operational and performance** characteristics of newly developed reciprocating engines.

• **Propellers** under high-altitude and high-power conditions.

• **Operational and performance** characteristics of jet-propelled aircraft and turbojet and ram-jet engines.

▶ **N.A.C.A. Wind-Tunnel Chief**—Made Chief of the Wind Tunnel and Flight Division in 1945, he has the responsibility of directing research in the Cleveland altitude wind tunnel, icing research tunnel, supersonic wind tunnels, and in flight.

Author of numerous N.A.C.A. reports, Mr. Silverstein presented a paper at the first joint I.A.S.-R.Ae.S. Meeting in London, September, 1947. He is a member of the High Speed Aerodynamics Sub-Committee of the N.A.C.A. and a Fellow of the Institute.

I.A.S. Sections

Baltimore Section

David P. Samson, Jr., *Secretary*

Following a business session, Charles Froesch, Chief Engineer of Eastern Air Lines, Inc., outlined the basic functions of an air line in a talk entitled, "What Is Air-Line Engineering?" G. N. Mangurian, Vice-Chairman, presided at the meeting attended by 105.

▸ **Three Divisions**—In his talk, Mr. Froesch stated that air-line engineering can be divided into three principal divisions: aircraft investigations, flight engineering, and maintenance engineering.

Each of these divisions was described and various problems that had arisen during actual operation of an air line were presented. The talk was illustrated by excellent slides.

Dayton Section

E. W. Robischon, *Secretary*

Following a dinner March 26, attended by about 65 members and guests, Major Gen. Franklin O. Carroll, U.S.A.F., presented a talk in the Engineers Club to a group of some 150 persons. The meeting was presided over by Lt. Col. A. A. Arnhym, Chairman.

▸ **Research Trends**—Subject of General Carroll's talk, "Air Force Research and Development Trends Within the Air Materiel Command," covered the highlights in research and development as carried out by various laboratories of the Command's Engineering Division.

A sound film was run showing test flights of the XB-47, YB-49, XP-86, and the track landing gear on the A-20.

Detroit Section

The March 9 meeting, Wilbur C. Nelson, Chairman, presiding, had as its guest speaker, Thomas J. Harriman, Project Engineer, Bell Aircraft Corporation, who spoke on "Advancements in Helicopter Utility and Economy."

▸ **"Dollars-Cents" Discussion**—In a down-to-earth, dollars and cents discussion of the commercial utilization of the 'copter, Mr. Harriman mentioned the tremendous strides made in helicopter utilization in the first year of commercial operations just past.

As specific instances of the value of 'copter operations, the use in crop dusting and blowing of water off cherries was mentioned. About 100 hours of flying time will save a $10,000 crop of cherries from spotting and splitting. Other uses include topographic mapping and geologic surveys.

▸ **Lift Rather Than Speed**—Latest developments stress lift rather than speed, since at the present stage there is little likelihood that helicopters will compete with conventional aircraft in that category.

In order to increase lift with as little sacrifice in speed as possible, two-speed transmissions will probably be used in the future.

Maintenance problem has been considerably reduced by provision for access to all mechanical parts. Along the same lines, improved components have increased the inspection time from 100 hours to 300 hours in the last year.

▸ **Solo in 7 Hours**—In answer to a question, Harriman stated that an experienced pilot could solo a helicopter in about 7 hours; a novice, with no previous flying experience, could be taught in approximately 50 hours.

Los Angeles Section

John C. Silliman, *Secretary*

A dinner and technical session was held April 6 with Vice-Chairman Frank Wagner presiding. About 160 were in attendance. The President of the French Messier Company, Rene Lucien, and Technical Director of the British Messier Company, Hugh Conway, were present.

▸ **Power System Specialists**—Mr. Wagner introduced Dr. M. U. Clauser, who presided as interlocutor for the program concerned with "Developments in Mechanical Power Systems." Dr. Clauser, following introductory remarks on different types of power systems to be considered, introduced the power systems specialists, who gave discussions in the fields of hydraulic, pneumatic, and electrical systems. These specialists included F. O. Hosterman, Lockheed Aircraft; Homer Wood, AiResearch; George Alamassy, General Electric; David Grant, Hughes Aircraft; H. F. Gerwig, Convair; and Fred Foulon, Douglas, El Segundo.

▸ **Electrical Systems**—Mr. Alamassy traced the trend of electrical systems used in aircraft in recent years and emphasized that these systems have grown to such an extent that 250 kw. of power are not unusual.

Radar, turrets, and toilet flush valves are a few of the mechanisms that are now operated by electrical systems—a far cry from the original purpose of the generator.

▸ **Hydraulic Systems**—Mr. Hosterman outlined some of the advantages of the hydraulic system, including its long life, large capacity for size, simplicity, and ability to handle quick changes in loads.

Such a system, he said, has a smoothness of control and could be expected to have an overall efficiency of 85 to 90 per cent.

High-temperature problems were conceded to be troublesome.

Mr. Grant described a device to move a plunger 3 in. with a 3,000-lb. force over an elapsed time of 3 sec. and showed that only a hydraulic system could handle the job.

▸ **Pneumatic Systems**—Some of the advantages of the high-pressure pneumatic system were outlined briefly by Mr. Gerwig. These included higher horsepower for less weight, absence of fire hazards, easy maintenance, ability to store potential energy before take-off, fuel savings, good temperature control, small size of lines required, etc.

The case for low-pressure pneumatic systems was presented by Mr. Wood, who was particularly interested in gas turbines: they give such a "nice source of compressed air."

Cross-questioning between the speakers and open discussion from the floor brought forth many further points of interest.

Calendar

I.A.S. Section Meetings

DAYTON—June 24
(Tentative)

Speaker: Dr. Hugh L. Dryden

HAGERSTOWN—June 9

Washington Co. Museum—City Park

Speaker: Sam A. Gordon
"Fatigue of Large Components of Aircraft Structures"

HAGERSTOWN—July 14

Washington Co. Museum—City Park

Speaker: Vincent J. Berinati
"Simplified Structure of Fairchild Personal Airplane"

LOS ANGELES—June 10

Rodger Young Auditorium

Speaker: To be announced
"Radio Navagation Aids"

WASHINGTON—June 9

Chamber of Commerce of the U.S.A.

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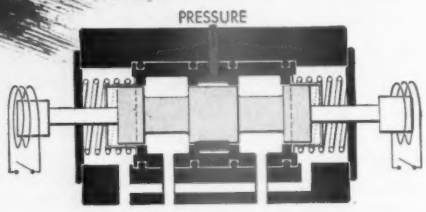

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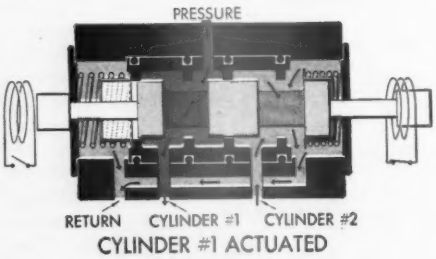

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New York Section

E. M. Lester, *Secretary*

The April 2 meeting featured Dr. Lynn L. Bollinger, Associate Professor, Harvard Graduate School of Business Administration, who talked on "Needed Design Development Improvements for Personal Aircraft." W. R. Enyart, Chairman, presided.

▸ **Basic Faults**—Dr. Bollinger set forth the results of his survey of the personal aircraft industry, including manufacturing, operations, and merchandising. As a result, he concluded that the American personal-plane industry suffers from certain basic faults.

Chief of these is that aircraft designed to operate from large airports result in the restriction of private planes to operating bases inconvenient to most private owners. This inconvenience, in turn, decreases the utility of the aircraft to the owner and promotes the high rate of aircraft turnover among present owners today.

▸ **Further Research Recommended**—Dr. Bollinger proposed the development of new personal plane types capable of meeting this objection. Although he admitted that such aircraft might require unconventional designs, he recommended further research in conventional designs, since he believed material improvements possible.

Philadelphia Section

John Rogers, *Secretary*

At the March 30 meeting, Col. Leslie E. Simon, Director, Ballistic Research Laboratories, Aberdeen Proving Ground, Md., presented a talk on "The Aerodynamics Work of the Ballistic Research Laboratories in the Transonic and Supersonic Field." Chairman H. Russell Young presided at the meeting attended by 55 members.

▸ **Wind Tunnel Work**—Colonel Simon, a West Point graduate who has done considerable graduate work at M.I.T., covered wind-tunnel work, new demands for sensitivity in tunnel instrumentation, free-flight instruments in the aerodynamics range and appropriate interpretation of the measurements, full-scale free flight at White Sands, and the correlation of all these types of experimental techniques with the latest advances in calculation of airflow by means of high-speed digital computing devices such as ENIAC.

San Francisco Section

Roy T. Nilsen, *Secretary*

Members of the Section heard Edward H. Heinemann, Chief Engineer, Douglas Aircraft Company, Inc., El Segundo Plant, deliver a talk at the February 12 meeting on the engineering problems, design, and construction details of the D-558 Project, involving the Skystreak and the Skyrocket Navy research planes.

▸ **Navy, N.A.C.A., Douglas Team**—Principal agencies involved in the project are the Navy, N.A.C.A., and Douglas. The project was originated for the purpose of carrying out a large-scale flight-test research program using piloted aircraft to obtain aerodynamic data required for the efficient and safe design of future high-speed aircraft approaching the speed of sound.

For this purpose the D-558 turbojet-powered Skystreak and the D-558-2 turbojet- and rocket-powered Skyrocket were designed, constructed, and flight-tested.

Seattle Section

Vaughn Blumenthal, *Secretary*

Five speakers featured the March 10 meeting attended by 280 members and guests. Chairman Jere Farrah presided.

E. C. Wells, Vice-President—Chief Engineer, Boeing Airplane Company; Charley Plum, General Electric; Dan Hage, Boeing Propulsion Unit Chief; Jack Lidral, Boeing Propulsion Unit; and Harold Warden, Manager, Installations Department, Curtiss-Wright Propeller Division, were the chief speakers.

▸ **Matching Problems**—Mr. Wells gave a general survey of the problems met in matching planes and power plants. In this respect, he classified the various power-plant types as to use in obtaining speed, range, and altitude performance and indicated the availability of each to the industry.

▸ **Gas Turbine Development**—Mr. Plum discussed with slides the chronological development of the gas turbine in the General Electric Company, ending with the present TG-180.

▸ **Relative Range Available**—The relative amounts of range available from existing rocket, ram-jet, turbojet, and turboprop power plants was illustrated graphically by Mr. Hage. In addition, he made some interesting comments on the required growth in rocket power plants to meet ranges presently available with turboprop units.

▸ **Steps Taken by Prop Industry**—Indicating the steps being taken by the propeller industry in meeting the challenge of new propulsion units, Mr. Warden outlined how the manufacturers expect to handle higher horsepowers, high speeds, high altitudes, etc.

▸ **Small Gas Turbine**—Work in progress on the Boeing small gas turbine was described by Mr. Lidral who gave some information on present design difficulties and operating time.

He illustrated the gas turbine laboratory and manufacturing facilities at Boeing with slides.

Wichita Section

J. H. Gerteis, *Secretary*

Meeting April 6, members of the Section heard N. B. Berboth, Sales Engineer of Beech Aircraft, on "Economic Aspects of 1948 Four-Place Aircraft." Chairman Tom Salter presided.

▸ **Costs Compared**—Mr. Berboth had prepared cost tables comparing all new four- and five-place airplanes on an hourly operating basis. The importance of high performance with low cruising horsepower was clearly illustrated in the tabulated figures.

When compared with other means of transportation, the four-place personal plane proved more economical than bus, train, or scheduled air liner, according to Berboth's figures.

▸ **Predicts Increased Use**—The speaker predicted an increasing use of four-place planes and a decrease in the use of two-place types as a medium of transportation.

It was stated that once the traveling public becomes aware of the low cost of air travel in the modern four-place plane increased plane ownership will result.

Student Branches

Aeronautical University

With an attendance of 116, the Branch held its April 6 meeting, Vice-Chairman F. S. Biggan presiding.

The Educational Project Committee outlined plans to photograph various engineering mechanisms. The prints will be enlarged and placed in each classroom of the engineering building.

Showing of the film, *Phantom*, produced by McDonnell Aircraft Corporation, concluded the meeting.

Aero Industries Technical Institute

Organizational meeting of this new Branch was held March 31.

(*Continued on page 85*)

Winner of Tri-University Contest: *William A. Hindenlang (2nd left), University of Detroit I.A.S. Student Branch member, judged winner of the student technical paper competition, is shown receiving the plaque and individual trophy from Robert Insley, Continental Motors Corporation. Looking on are (left to right): Kenneth R. Herman, Vickers, Inc., and B. J. Simons, Stinson Aircraft Division, Convair, who acted as judges with Mr. Insley in the contest.*

Editorial

It's Your Library—

—so, why not make more use of it? The Institute has in its libraries the greatest collection of useful tools for the aeronautical engineer which has ever been assembled. Its two library facilities, one East and one West, stand ready at any time to supply the needs of I.A.S. members, individual and corporate, for the latest available information on any subject of, or related to, the aeronautical sciences. What, for example, is the latest on pulse jets?—wave drag?—wake survey methods?—helicopter blade forces in forward flight?—or any of a thousand questions that come up in your day's work. Just ask us. If we don't know at the moment, we will do our best to find out!

Out in our Hollywood office, Mrs. Nell Steinmetz and her efficient staff are handling hundreds of such questions every month and, at the same time, are supplying to industry subscribers a unique card indexing service that keeps its members posted daily on the latest articles and reports as they appear in print. The Institute's Pacific Aeronautic Library is rapidly outgrowing its present quarters, and plans are afoot to provide more space and more efficient housing for it in the new Los Angeles Facility building which we hope will be erected shortly.

In New York there is no immediate housing problem, for our libraries occupy well-planned space in the 64th Street building. There, the Burden, Kollsman, and other Institute collections are available for the use of Institute members. Mr. Maurice Smith and his group receive, screen, and classify thousands of books, magazines, pamphlets, and reports yearly. There are few aeronautical publications from anywhere in the world that do not pass under their scrutiny. There are few languages in print that cannot be read by some staff member.

The New York library staff works hand in glove with the editorial staff of the AERONAUTICAL ENGINEERING REVIEW. Every month, the REVIEW brings to I.A.S. members a digest of the literature received in the library, right up to the closing date of each issue. The library staff is now preparing a complete listing of all items published in the REVIEW for 1947, classified according to the latest Standard Aeronautical Indexing System. This 100-page volume will be available shortly. Similar bibliographies will be published every year. This is a new service for I.A.S. members.

Both I.A.S. libraries are official repositories for the Air Force microfilms of captured German and Japanese aeronautical documents. Thousands of feet of film are available for the use of Institute members. They are indexed to assist you in finding whatever specific information you need. Film viewers are available in the reading rooms.

Requests for our library services come by telephone, telegram, cable, and letter, as well as in person. One engineer obtained quick information by telephone which would have cost him half a day's time to come and get himself. By long-distance telephone, a company president obtained a book he had been seeking and unable to find locally. A member stationed on a ship in the Pacific obtained by mail the information he needed to solve a design problem beyond the scope of his available information. A company librarian was able to fill a request for half a dozen foreign reports that were badly needed in Engineering in a matter of 24 hours, rather than in weeks. A member in the Middle West was saved many hours of time because our Library could furnish him—by return mail—a translation of an important article from a foreign periodical.

These are only a few samples of the services that I.A.S. libraries, East and West, are furnishing to its membership. We are unique in that we are one of the few professional societies that maintains its own specialized library services for the convenience of its members. We have excellent physical facilities, manned by highly trained and competent people. They stand ready to serve your needs at all times. Remember, these are *your* libraries. Make full use of them.

S. P. J.

I.A.S. New York Facility Reading Room

Research Toward Greater Seating Comfort*

KENNETH R. JACKMAN†

Consolidated Vultee Aircraft Corporation

ABSTRACT

Emphasis has been placed in the Convair Laboratories over the last several years on specific applied research in comfortable seating.

The development of the current lightweight Convair double passenger seat is described, together with the part played by the laboratory research in Fiberglas cushions toward greater seating comfort. The use of such test aids as the "Dynamic Cycler" to accelerate life tests on seats and cushions, the "Single and Multiple Indentors" for spring-rate determination, and the "Vibrindex" and "Ridometer" in ride characteristic identification is discussed.

A bibliography of over 30 sources is presented to show the current status of transportation comfort.

INTRODUCTION

BEARING IN MIND that but for the presence of the passenger there would be no air line to operate, it is reasonable to give high priority, when planning a comfortable air-liner's cabin, to the seat that this passenger will have to occupy.

Certain it is that in no item of aircraft design are there so many individual opinions as on seating. Every man questioned will have definite ideas of his seating comfort, for who can tell him when he is comfortable or ill-at-ease? It is with some temerity, therefore, that the writer discusses this controversial subject of aircraft seating, for he agrees with Morris[13] that "all people must be compromised in the comfort of the chair in which they must be seated," and the extent of this compromise will depend upon weight, space available, styling, type of aircraft, and many other factors.

Because of space and the writer's limitations, the discussion on seating will be narrowed to apply to passenger seating in adjustable or reclining type chairs. Berthable or sleeperette type aircraft chairs are more limited in their immediate use and pose many special weight and design problems that may not interest the majority of the readers.

Condensed version of paper presented at the Air Transport Design Session, Sixteenth Annual Meeting, I.A.S., New York, January 26–29, 1948.

* Portions of this paper are based on research and development in aircraft acoustics and seating comfort made by Consolidated Vultee Aircraft Corporation. The author is indebted to Convair, at San Diego, for permitting the publication of this material. Particular appreciation is expressed for the invaluable test aid and suggestions extended by Dr. C. J. Krieger and Mr. V. S. Harrison, of the Convair Engineering Test Laboratories, who performed much of this passenger-comfort research.

† Chief of Test Laboratories, San Diego Division.

THE BASIC SEATING PROBLEM

Inasmuch as seat and riding comfort in any vehicle is essentially the same, the study of the factors involved in automotive seating has always been the prerequisite to further consideration of aircraft seats and cushions. Tea,[30] Paton, Pickard, Hoehn,[21] and Lay and Fisher[10] have been the "bibles" of the aircraft-seating engineer, which, with the riding fatigue studies of Moss,[15, 16] have been the starting point of much aircraft research on the most economical basis.

In 1935, at the instigation of The Murray Corporation of America, there began at the University of Michigan, under the direction of Lay and Fisher,[10] a study of the automobile cushion and its function in the transportation of passengers with greater comfort and less fatigue. Constructed for this purpose was the elaborate piece of apparatus called the "Universal Test Seat," whose dimensions were completely adjustable, with arrangements to vary the distribution of the supporting pressure in any manner that seemed most comfortable to the passenger.

Lay and Fisher,[10] after studying 250 subjects on this Universal Test Seat, concluded that to give the passenger the maximum comfort and least fatigue the following mechanical objectives should be attained by the cushion under static body loads:

(1) To support the passenger over a large area to get the smallest unit pressure on the flesh.

(2) To avoid variations in pressure from point to point over the supported area except those variations dictated by actual variations in the body of the passenger. (To obtain the surface contour and pressure distribution on the loaded cushion that is considered by the average passenger to be the most comfortable.)

Under *dynamic* body loads for comfort the cushion should be designed:

(1) To avoid large changes in pressure or forces acting on the body of the passenger with respect to time. (Least muscular exertion to maintain equilibrium.)

(2) Especially to avoid high rates of change, with respect to time, of either the values or direction of pressures or forces acting on the human body.

With the various shapes and weights of loading forms now used by the automotive industry, it is obvious that more "standarized" anthropological measurements of the average passenger need to be applied to seating.

Basic Body Dimensions and Seat Loading

The comfort of modern seating can be claimed to have started almost 60 years ago, when some Army surgeons, wishing to distribute the weight of a soldier's marching equipment so that his marching posture would still be normal, cut up a number of frozen cadavers, weighed the parts, found the locations of the centers of gravity, and the dimensions of each part. Their average weight distribution data are still basic references.

It is interesting to note from the normal (and comfortable) attitude of a hinged manikin that, through sheer biological laziness, man stands with the compression links, such as the upper and lower leg, on dead center so that the position may be maintained with the least muscular exertion, a good prehistoric engineering concept. So too, when seated, man's muscles must be at rest to prevent fatigue.

The weight of the seated man's feet, lower legs, and a part of his thighs is carried on the floor, all the rest of the body is supported by the seat and back cushions if he is in repose. These weights total 153.4 lbs. for the average man, who in the reposed seated position would apply approximately 125 lbs. on the seat cushion. This has been chosen as the standard Convair "buttock form" weight. Similarly, a 160-lb. "buttock form" weight was chosen by the Riding Comfort Laboratory for the 200-lb. man.

The most recent thorough survey of body measurements relative to the design of seats was made for the Heywood-Wakefield Company, of Gardner, Mass., by E. A. Hooton, of Harvard University. While his study was not one of posture, comfort, or fatigue, it is believed that comfort cannot be obtained or fatigue reduced without an accurate knowledge of body dimensions. After measuring almost 3,900 adults, Hooton prepared the tentative recommendation for average seat dimensions shown in Table 1.

Table 1
Tentative Recommendations for Dimensions of Seats (Hooton[6])

Dimension	Measurement (In.)
Seat length	20.0
Back height	28.0
Elbow height	8.5
Hip breadth	19.0*
Shoulder breadth	19.0*

* Hooton's Note: The recommendations of 19 in. for hip breadth and shoulder breadth are not based upon optimum conditions but upon the restrictions of maximum overall seat breadth of 44 in., as described to Harvard University. These recommendations are, then, a compromise. Nevertheless, the dimensions thus recommended should be adequate for more than 85 per cent of the traveling public. Seat height is 16.9.

Most of the aircraft-seat manufacturers, represented by seat designs varied to their individual styling and taste, nevertheless follow some of those basic dimensions until compromised by some more vital factor. Morris[13] has added a new chapter to the design of aircraft seats in the reclined or relaxed position. He contends that the consideration of the human skeleton as rigid, segmented members proves inadequate when attempting to provide comfort in the reclined position. His relaxed passenger demands a variation in the Hooton seat dimensions listed above.

Fig. 1. "Luxurity" and style in "Convair-Liner" seats.

Aircraft-Seat Manufacturing

Weight has been the most restrictive feature in aircraft-seat design. To obtain adequate passenger comfort at the light weight they desired in the new transport, Convair designed and built the present Convair-Liner double seat. From the initial structural assembly and welding to the installation of the Fiberglas seat and back cushions, the objective has been passenger comfort at a minimum weight. The overall appearance in Fig. 1 had to meet rigid tests by air-line stylists, and the comparison with other current air-line seats has brought many favorable comments.

The quality and maintenance of an aircraft seat is only as good as its weakest part, so Convair designed each detail of the seats with care, maintaining light weight with adequate structural strength to meet all flight loads specified by C.A.A. A detailed weight

Table 2
Typical Weight Analysis of Convair Dual-Passenger Seat

Item	Weight, Lbs.	Per Cent—Total Weight
Structure		
Frame assembly (welded)	12.00	24.0
Back structure (2)	8.40	16.8
Arm rests (2)	7 45	14.9
Shrouding	1.64	3.2
	29.49	58.9
Seats and Back Cushions		
Seat cushions (2)	6.60	13.2
Seat covers (2)	1.70	3.4
Back cushions (2)	3.72	7.5
Back covers (2)	3.80	7.6
	15.82	31.7
Miscellaneous		
Seat locks (2)	2.30	4.6
Ash-tray assemblies (2)	0.76	1.5
Seat belts (2)	1.40	2.8
Miscellaneous hardware	0.23	.5
	4.69	9.4
Totals	50.00	100.0

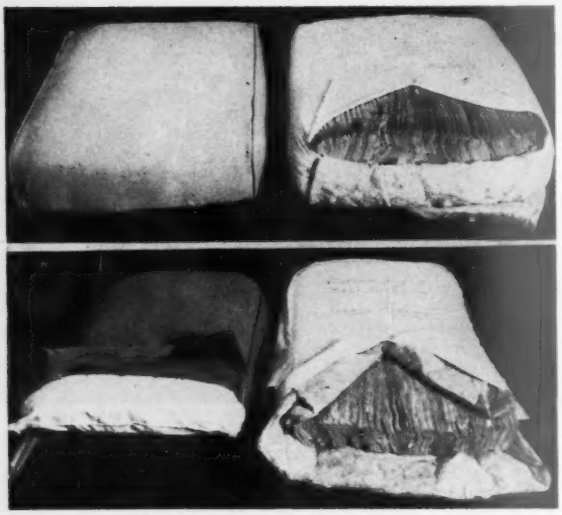

FIG. 2. Convair Fiberglas cushions.

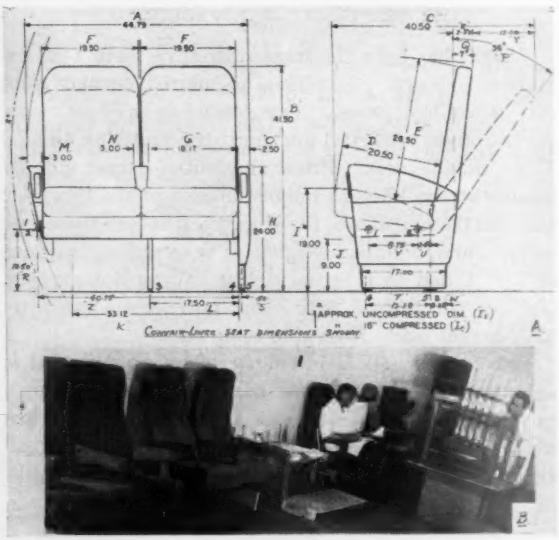

FIG. 3. Comfort depends on proper seat dimensions.

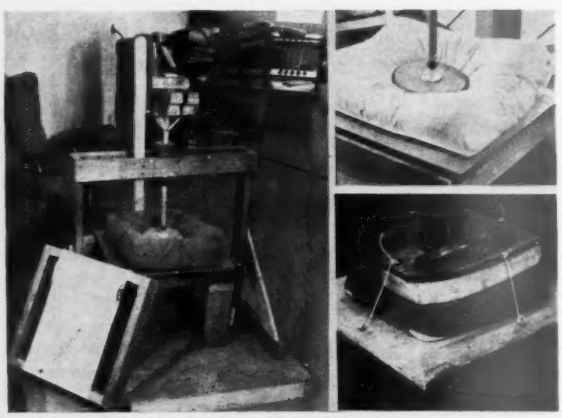

FIG. 4. Cushion "Single Indentor" at Convair.

analysis of this Convair 50-lb. double chair, shown in Table 2, indicates why it was so important to develop a lightweight cushion material for the seats and backs.

Fig. 2 shows the external appearance of the Convair-Liner Fiberglas seat and back cushions and details of the Fiberglas batt assembly. The $^1/_2$-in. B-fiber batts are assembled and cemented so that the density of the "on-end" layers varied from lightest at the front to heaviest at the rear, conforming to the normal human posterior loading during relaxed riding conditions. Following this Fiberglas assembly, the exterior surfaces are latex-sprayed by a method developed by Convair. With a thin overlying sheet of Fiberglas and an enclosing muslin case, the 3.3-lb. seat cushion and 1.9-lb. back cushion offer a lightweight goal difficult of attainment by foam latex, spring, rubberized hair, or any other currently known cushioning material.

Comparison of the basic Convair-Liner seat dimensions of Fig. 3 with Hooton's recommendations of Table 1 indicates that this new chair is within the acceptable comfort standards for modern short-haul transports.

SEAT-CUSHION DEFORMATION IS IMPORTANT FOR COMFORT

Fig. 3 shows one corner of the Convair Riding Comfort Laboratory in which Dr. Charles Krieger and his aides have done much to identify comfort factors in airplane seating. The "Multiple Indentor" is shown in use, measuring the deformation of a Fiberglas cushion under simulated body weights.

The Rubber Manufacturers Association, Inc., has specified in their Buyer's Specifications[4] for "Latex Foam" the indentation test for measuring the load necessary to produce a 25 per cent indentation in the sample. The apparatus specified for this test shall have a flat circular indentor foot 50 sq.in. in area (approximately 8 in. in diameter), connected to a load measuring device, by means of ball-and-socket joint and mounted in such a manner that the product or specimen can be deflected at the approximate rate of 25 in. per min. The apparatus shall be arranged to support the specimen on a level, horizontal plate that is perforated with $^1/_4$-in. holes on $^3/_4$-in. centers to allow for rapid escape of air during the test. The indentation shall be made at the center of all articles, using a preload of 1 lb. prior to measuring initial height.

Fig. 4 shows the "Single Indentor" adaptation of the rubber Buyer's Specification[4] used at Convair for aircraft seating. Cushions are tested either on the hard base shown or on the "spring base" resembling the seat suspension with its coil-spring loaded canvas. Inasmuch as the newly developed Fiberglas cushions vary in hardness and spring rate from front to rear, it is the practice on a research cushion to check a front, center, rear, and one lateral center location for load deflection. The weight pan, at the top of the vertical rod that rides in bearings, can be loaded in increments to the 125- or 160-lb. load. A deflection scale on the vertical

rod, or adjacent to it, makes possible a rapid determination of the cushion thickness.

Fig. 5 shows the cushion thickness, measured on a hard base, versus the "Single Indentor" reading of a light-weight Fiberglas cushion ("B" fiber, 2.46 lbs.), a cored airfoam cushion (3.56 lbs.), and a cored airfoam with Fiberglas rolls (4.53 lbs.). The differences in the cushion thickness on loading and unloading and the hysteresis curve for front and rear areas on the "B" fiber cushion are quite marked. The spring constant for a 107-lb. load on the Fiberglas "jelly-rolls" in cored airfoam (33 lbs. per in.) indicated similarity to that for several 1947 automobile seats. (Car A, 31 lbs. per in., and 1947 car B, 28 lbs. per in.)

Although Tea[30] many years ago warned that "a direct concentrated load test on a cushion for measuring deflection has no definite relation to comfort and, for that reason, must be used with caution," the writer and Dr. Krieger have felt for some time that some deflection method that would measure indentation on a cushion similar to that produced by the human posterior (buttock form) might prove valuable in predicting permanent set during cycling operations. For this reason the Convair "Multiple Indentor" was developed, as shown in Fig. 6. By loading each of the 23 spindles, each terminating in an articulated 2 by 2-in. pad at the cushion contact area, with its portion of the 125- or 160-lb. standardized loadings shown in the sketch on Fig. 6, a deflection of the cushion occurs in the shape produced by the "sitter." Inasmuch as each vertical rod carries its own deflection scale, rapid readings may be made of cushion deformations. Thus,

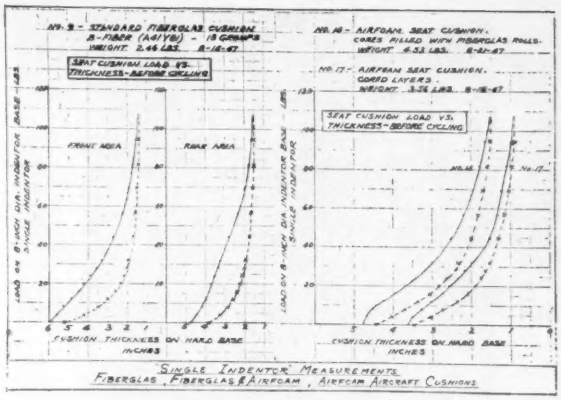
SEAT CUSHION LOAD VS. THICKNESS - BEFORE CYCLING
FRONT AREA
REAR AREA
CUSHION THICKNESS ON HARD BASE INCHES
SEAT CUSHION LOAD VS. THICKNESS - BEFORE CYCLING
CUSHION THICKNESS ON HARD BASE INCHES
SINGLE INDENTOR MEASUREMENTS
FIBERGLAS, FIBERGLAS & AIRFOAM, AIRFOAM AIRCRAFT CUSHIONS

FIG. 5.

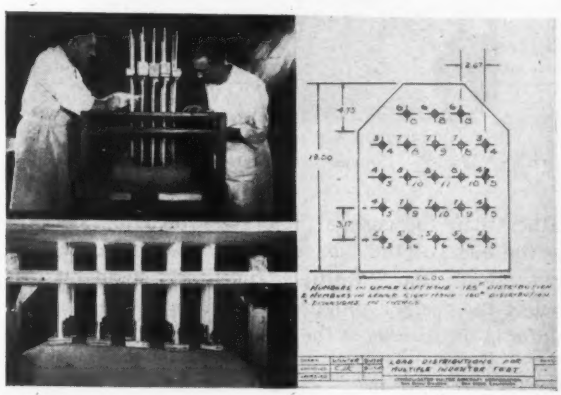

FIG. 6. Convair "Multiple Indentor" for accuracy.

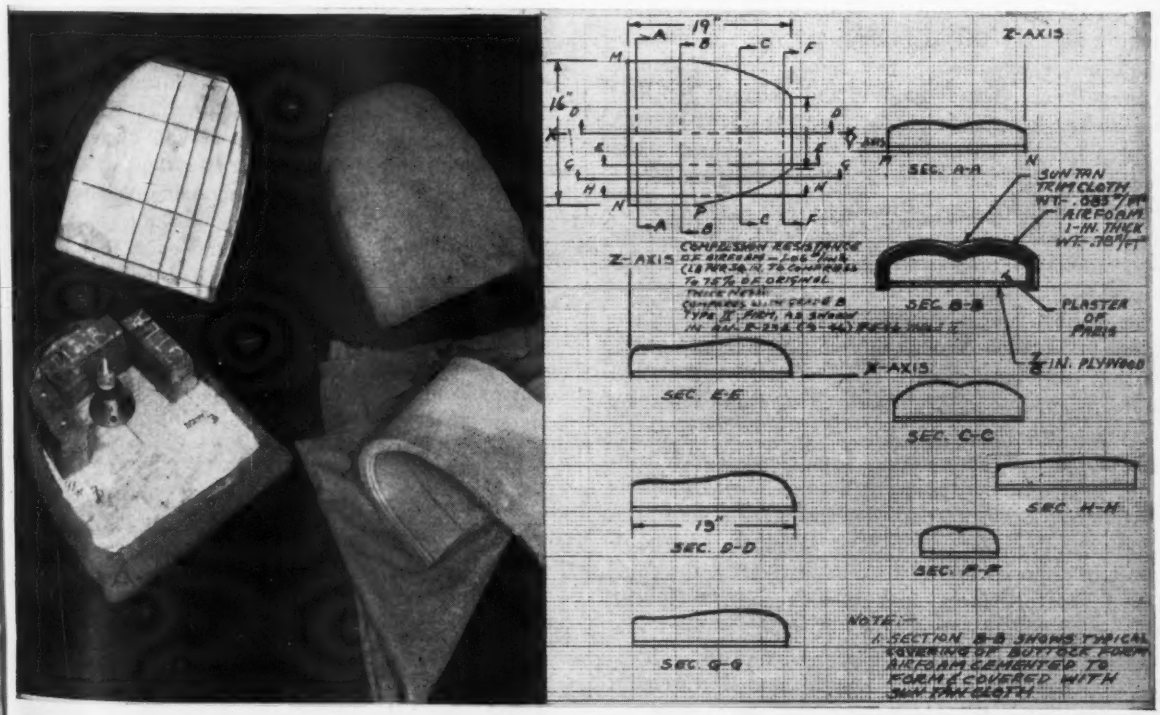

FIG. 7. Convair "Buttock Form" dimensions.

FIG. 8. Convair seat "Dynamic Cycler."

rather than the cushion upholstery breaking sharply at the edge of the 8-in. diameter "Single Indentor" under load, the "Multiple Indentor" spindle pads deflect the cushion progressively from outside edge to center in the manner of the human buttock form.

STANDARDIZED LOADING OR "BUTTOCK FORMS" ARE ESSENTIAL

The author has not been successful in finding anthropologic measurements of the posterior of the average man in all the referenced literature. So a member of the Convair Engineering Test Laboratories, a man of average build, 5 ft. 8 in. tall, and weighing 155 lbs., was seated in a pan of moist clay, separated by wax paper, and a "buttock form" was developed. The contours of this Convair standarized "buttock form" are shown in Fig. 7 and are available upon request. To these plaster forms were cemented reinforced plywood tops to permit attachment to the loading apparatus.

Recently, there has come to the writer's attention another "buttock form" that may be as "standard" as that used by Convair. This is used by the Ford Motor Company and by the Owens-Corning Fiberglas Corporation in their seat tests.

After each plaster cast had been covered with 1-in. thick sponge rubber (grade B, Type II, Firm, of Specification AN-R-23a of a unit weight of 0.78 lb. per sq.ft.) and aircraft woolen trimcloth (Seaman "Suntan" fabric of approximately 0.085 lb. per sq.ft.), the completed "buttock form" and its universal attachment weighed approximately 58 lbs. A universal joint was placed $8^1/_2$ in. forward of the rear edge of the "form" (or 45 per cent of its 19-in. length), and lead weights were symmetrically added near the pivot point to provide the 125- or 160-lb. test loads.

The Convair "buttock form" (Fig. 7) was purposely designed overly long so that approximately 2 to 3 in. of its 19-in. length overhung the test cushion shown in Fig. 8, thus preventing front-edge chafing. The effective area of the contacted 16-in. length is approximately 220 sq.in. The contours of the Ford seat form give an effective area of 193 sq.in. for the $15^1/_2$-in. length.

CUSHION CYCLING FOR LIFE PREDICTION

With an accurate deflection-measuring apparatus in the "Multiple Indentor" for determining the change in spring rates or permanent set, it soon became evident that life-expectancy tests could be made on the Fiberglas cushions and comparisons made with conventional seat suspensions and cushions now in service on the air lines. Convair developed a simplified version of "Dynamic Cycler," shown in Fig. 8, used by one of the automotive laboratories. This apparatus consists of a four-station life-cycler in which the Convair standardized "buttock form" loaded to 125 lbs. (for 150-lb. person) or 160 lbs. (for 200-lb. person) apply down and aft loads to test seats or cushions at approximately 24 times per min. The initial vertical offset of the loading arm and the table axes of rotation during the latter's "see-saw" operation, determine the ratio of vertical to fore-and-aft motion of the "form" over the seat.

A life expectancy of 100,000 cycles of the complete "sitting" process has been adopted by Convair as equivalent to approximately 5 to 8 years of aircraft service, and the initial cushion deformations, after a few shakedown loadings, are compared with those measured after 5,000, 10,000, 20,000, 50,000, and 100,000 cycles on the "Dynamic Cycler." Although duplications of aircraft passenger chairs now in service on some air lines failed to complete the 100,000-cycle test because of coil and zig-zag spring breakage, attachment failures, or wearing out of the mohair upholstery, the Convair-Liner 3.3-lb. Fiberglas cushion not only showed little indication of loading even to a supercritical observer by a "sitting" test but is still in laboratory use as a demonstration cushion.

Table 3 shows deflection measurements made upon a 3.11-lb. Fiberglas cushion (No. 25) by the two indentors, before and after the 100,000-cycle tests. It is obvious that the "Single" and "Multiple Indentors"

TABLE 3
Deflections on Fiberglas Cushion Before and After Cycling

	"Single Indentor"			"Multiple Indentor"		
No. of Cycles	Load, Lbs.	Defl., In.	Aver. spring rate, Lbs. per in.	Load, Lbs.	Defl., In.	Aver. spring rate, Lbs. per in.
0	107	3.50	31	125	3.28	38
100,000	107	3.39	32	125	3.17	39
100,000 (Full recovery)	125	4.10	30	125	3.41	37

reading cannot be interchanged but that they are consistent for a given method.

Seat-Cushion Vibration Tests

Another laboratory tool to correlate passenger subjective reactions and riding comfort with objective recorded instrument readings is seen in the Convair "Ridometer" of Fig. 9. This development, shown to the left mounted as a 150-lb. "observer" in an automobile riding test and on a Convair-Liner seat on the laboratory vibration table to the right, consists of a five-component photographic recorder to measure simultaneously the roll, pitch, and bounce, with timing and sequence indications, and of a weighted seat and cushion, in a vehicle on the ground or in flight.

Fig. 10 shows two schematic sketches inside the "Ridometer," with the light beams and optical system to the camera oversimplified. An actual photographic record is shown in the upper right corner to indicate the clarity of the traces and timing marks. The overall cost of such a "Ridometer" may be low, if war surplus gyrocompass units are obtainable. The inventor, V. S. Harrison, of the Convair Laboratories, was able to assemble much of this apparatus, together with the "Vibrindex" to be mentioned shortly, from surplus and in his spare time between more pressing research developments. The following "Ridometer" observations were made on a 1942 automobile in the laboratory to determine its overall spring resonances and those of the seat cushions. With a 150-lb. "Ridometer" right front seat load and a camera speed of 2.9 in. per sec., the results of Table 4 were recorded:

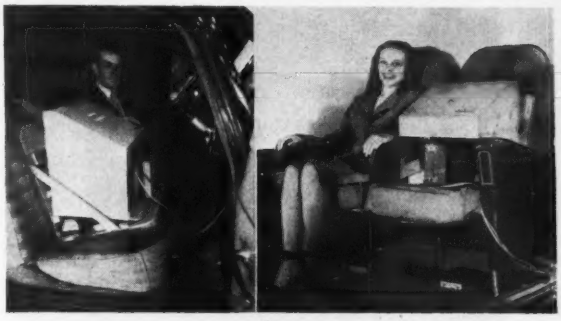

Fig. 9. Seat tests with the Convair "Ridometer."

Table 4
"Ridometer" Tests for Automobile Resonance Identification

Car	
Pitch, excited from front bumper	56 Cycles per min.
Pitch and bounce, excited from rear bumper	75 Cycles per min.
Roll, excited from right top	65 Cycles per min.
Car Front Seat	
Pitch, excited from top of "Ridometer"	200 Cycles per min.
Roll (well-damped), excited from top of "Ridometer"	250 Cycles per min.

Riding Comfort Demands Vibration Isolation

The Convair-Liner dual passenger seat is rubber shock-isolated at its five points of attachment, three to

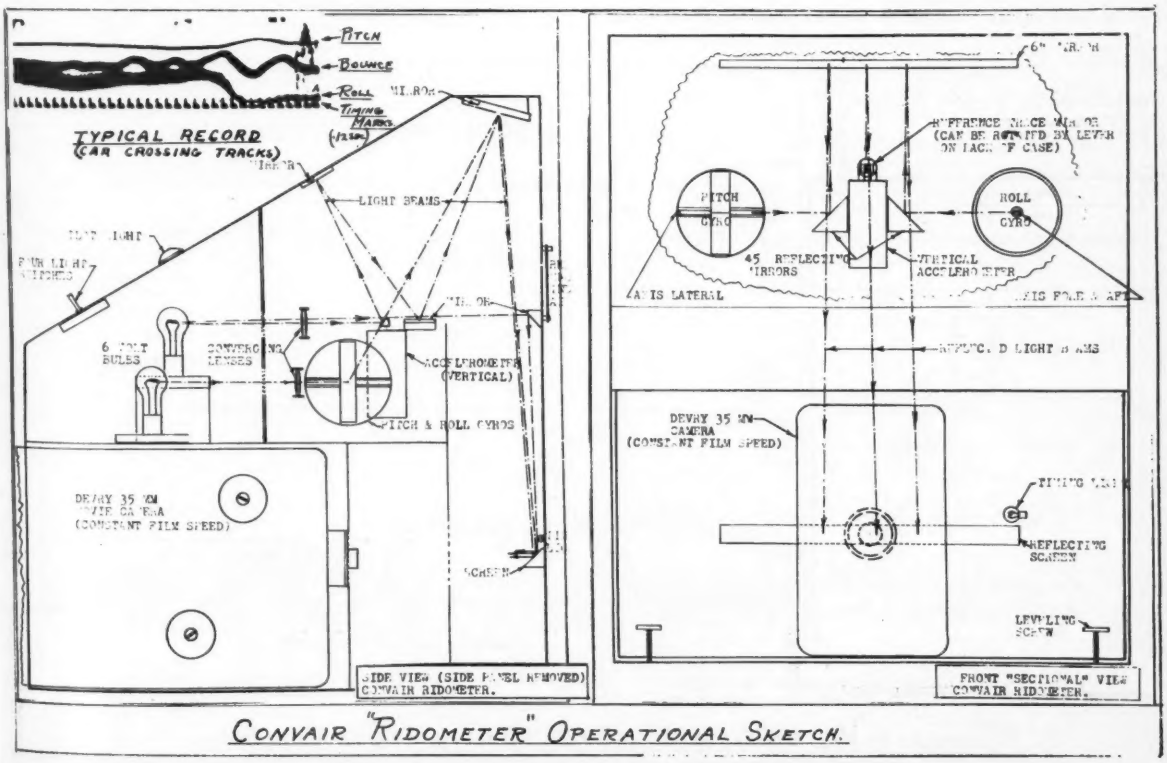

Fig. 10.

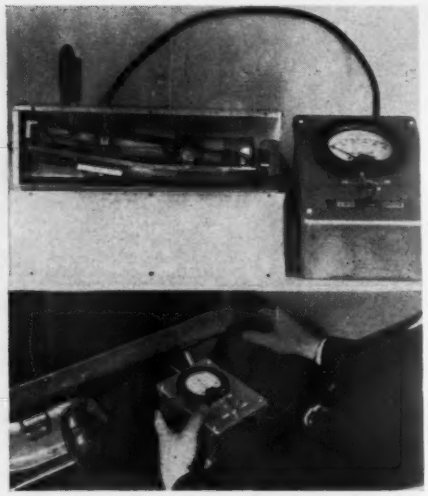

FIG. 11. Vibration tests with Convair "Vibrindex."

the cabin flooring and two to the fuselage side wall. The special "M-B" mounts in each chair leg and the heavy-duty shock absorbers at the wall attachments serve a twofold purpose: (1) the flexibility of the "Wedjit" fittings makes the installation and removal of seats easy and rapid, and (2) the rubber "O" ring fittings aid in vibration isolation.

To aid in the study of vibration transmittal to the passenger with its attendant discomforts, a member of the Convair Riding Comfort Laboratory developed the "Vibrindex" shown in Fig. 11. This instrument uses a horizontal pendulum to cut magnetic lines of flux, and a meter registers the results. Sufficiently sensitive elements to record the low-frequency oscillations (down to 54 cycles per min.), which are sometimes so uncomfortable to travelers in trains and buses, were not available on the commercial market when this "Vibrindex" was developed. An "M-B" velocity pickup head was used with the meter on some early railroad vibration surveys. However, replacement of the "M-B" pickup with the air-damped Convair unit shown in the upper photo of Fig. 11 gave considerable greater sensitivity, yet with good low-frequency response, as shown in Fig. 12. Note that low amplitudes (0.100 in.) are capable of being read in almost a linear relationship with frequency.

An interesting comparison of three automobiles was recently made at Convair, as shown in Table 5. Cars "A" and "C" were conventional in every respect and car "B" was an experimental model with a new type of suspension undergoing acceptability tests. The cars were driven over the same test course on Lindbergh Field, and readings were taken while passing the same mark on the course. The "Vibrindex" pickup was held rigidly on the dash to record vertical vibrations.

TABLE 5

"Vibrindex" Test Results on Automobile Riding Comfort Surveys

Speed, M.P.H.	Road Surface	Car A	Car B	Car C
20	Smooth macadam	4.0	15	0.5
30	Smooth macadam	6.0	18	2.0
40	Smooth macadam	7.0	22	3.0
20	Rolling concrete	4.5	22	1.0
30	Rolling concrete	6.5	28	2.5

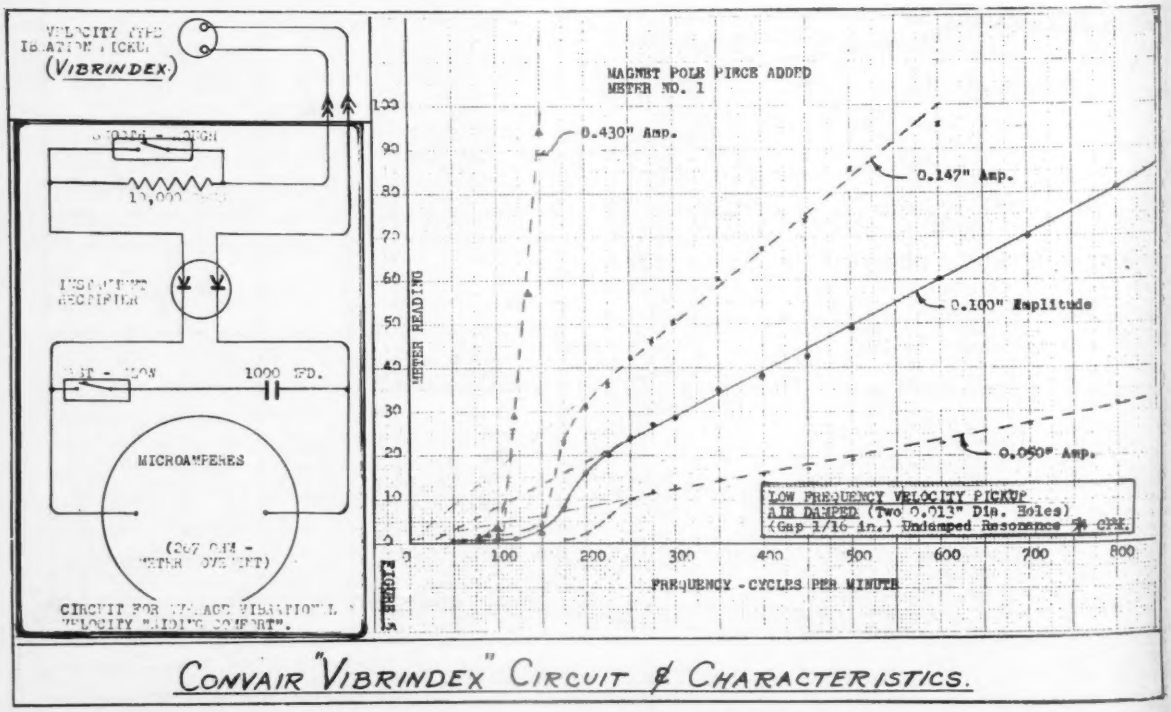

FIG. 12.

Summarizing, therefore, it may honestly be said that the air lines have become conscious of the comfort standards demanded by the air-minded public and are attempting to meet these desires in the modern air transports.

References—Seating and Riding Comfort

It is interesting to note the emphasis that has been placed on passenger comfort by the various means of transportation, some in the twenties and thirties, but becoming increasingly important within the last 2 years.

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National Flight Propulsion Meeting—Part II

Symposium on Design Problems of Turbojet Power-Plant Installations

by
Randolph Hawthorne

THE FOUR PAPERS of the Afternoon Session ranged from a simply stated exposition of the design problems confronting the jet aircraft preliminary design engineer to more particular aspects of turbine-powered planes, including duct efficiency and factors affecting inlet performance, design problems of exhaust systems, and problems involving accessory systems resulting from the increasing congestion in the power-plant nacelle.

In the first paper presented at the Symposium, Dr. Milton U. Clauser, Chief of Douglas Aircraft's Mechanics Section, who was introduced by the presiding Chairman, Robert J. Woods, stated the problem facing the preliminary design engineer as being greatly complicated by the development of turbojets, propeller turbines, pulse-jets, rockets, etc.

On the other hand, the new power plants have opened up new possibilities in the ubiquitous compromise between simplicity and efficiency by making it possible to get high output with light weight. However, as Dr. Clauser pointed out, the simpler or lighter an engine is, the less efficient it is.

The significant thing about the problem of engine compromise is that the designer cannot diminish the degree of compromise but can only shift the emphasis.

In the design of a relatively small turbojet or propeller turbine aircraft, there are four principal items that the preliminary designer must locate with respect to each other, bearing in mind the essential compromise between simplicity and efficiency. These are:

(1) The pilot should be forward for good visibility.

(2) Engine should be forward for good balance and clear of other equipment for accessibility. Scoops should be in the nose for good ram.

(3) Fuel should be near the center of gravity for trim.

(4) With thin wings, the main landing gear may be in the fuselage near the center of gravity. The nose wheel, of course, must be forward.

Three illustrations of compromise arrangements were given (Fig. 1): one favoring low drag and good ram; a second favoring accessibility and ram, using nacelles separating the engines from fuselage equipment; and a third showing a low drag arrangement for a propeller-turbine installation in the fuselage.

In the second illustration, the penalty paid for accessibility is in the higher drag of the nacelles; in the third, the propeller-turbine installation, difficulty is experienced in getting good accessibility.

An advantage of the nacelle arrangement is that some of the shrouding can be eliminated since the engine can be placed near the outside skin in such a way that fire from a broken combustion chamber or tailpipe could not impair the structural integrity of the plane. Otherwise, to afford adequate protection, it is necessary to install a stainless-steel shroud around the compressor and accessory section, isolating the high-pressure fuel system. Another stainless-steel shroud around the combustion and turbine section isolates this from any possible source of combustible fluids and prevents the structure from becoming overheated.

Abe Silverstein, Chairman of the Cleveland Section, with R. J. Wood and Milton Clauser.

Since the fuel tank is above the engine, it is shrouded with aluminum alloy and drained overboard. If the tailpipe terminates at some point within the plane, then a double stainless-steel shroud is required to prevent fire reaching inside the aircraft in case the primary shroud is cracked or broken.

In the more detailed phase of the preliminary design, two features of the engine are of considerable concern to the designer: the accessory drive and engine mounting arrangements.

Both flexible and rigidly mounted engine methods seem to be satisfactory for jet and turbine engines. From the airplane designer's point of view, it is better if the long thin jet engines are mounted at the ends, since that method is a much more natural way to carry this shape of an object. However, the tendency among the engine manufacturers has been to recommend flexible mounts located at the engine's c.g. and a stabilizing attachment at one end. This means provisions

must be made to accommodate large displacements of tailpipes and ducts.

The problem with accessories is that engines are getting smaller, while accessories are getting larger. It seems inevitable that, in spite of the difficulties involved, separately mounted accessories will have to be resorted to by the designer.

Following Dr. Clauser's talk on preliminary design problems of the jet air frame, William J. Blatz, McDonnell Aircraft Project Aerodynamicist, described the more particular problems concerning air induction systems, using by way of illustration the wing root inlet development in the FH-1 Phantom.

Aerodynamic requirements for an ideal induction system demand that it deliver air to the engine with no reduction in available energy, with no increase in drag and without compromising the high speed characteristics of the plane. To these might be added, in the case of certain axial flow installations, the necessity of maintaining uniform distribution over the compressor face.

Some of the factors affecting inlet performance are:

(1) In order to obtain satisfactory recoveries, separation of the flow over the duct lips must be prevented through an appreciable range of angles of attack;

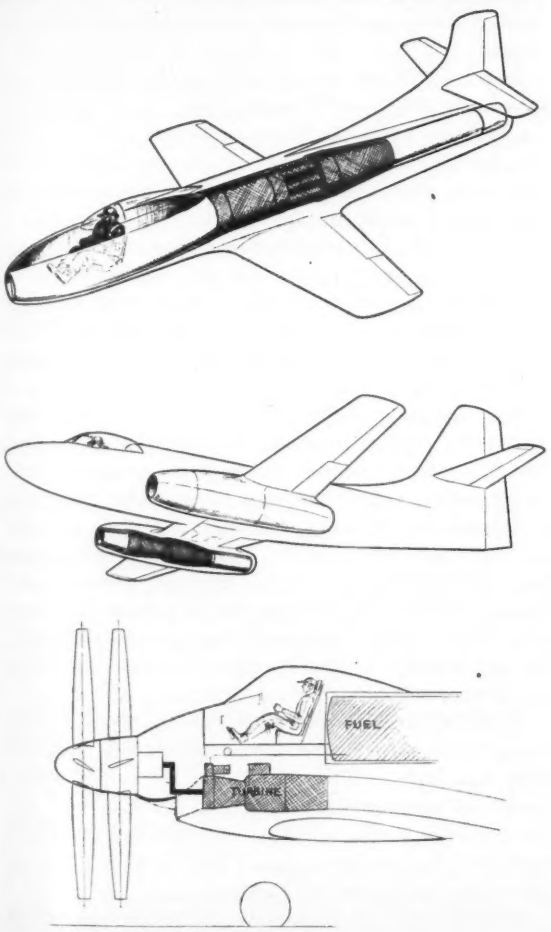


FIG. 1.

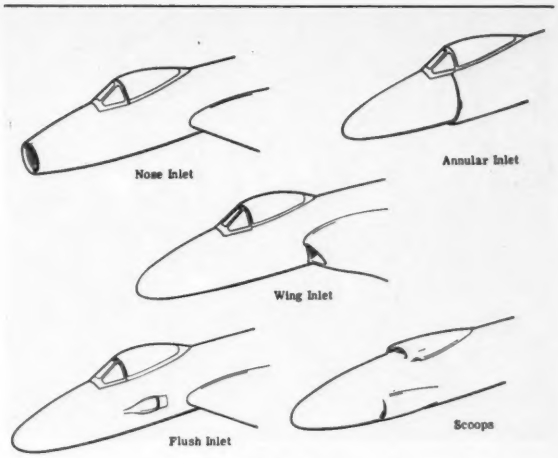


FIG. 2

to attain high critical Mach Numbers, induced velocities must be kept as low as possible.

(2) In addition to separation resulting from the stalling of the duct lips, large pressure losses may result from boundary-layer effects. These losses are twofold—first, from the fact that boundary layer is composed of low energy air, which, when taken into the duct, represents an inherent total pressure loss; second, often most costly, because of the positive pressure gradient that begins ahead of the inlet and continues throughout the length of the diffuser. This gradient results in a thickening of the boundary layer, which in turn may induce separation along the duct walls.

(3) There are further losses in any induction system caused by diffusion, bends, and skin friction in the internal ducting.

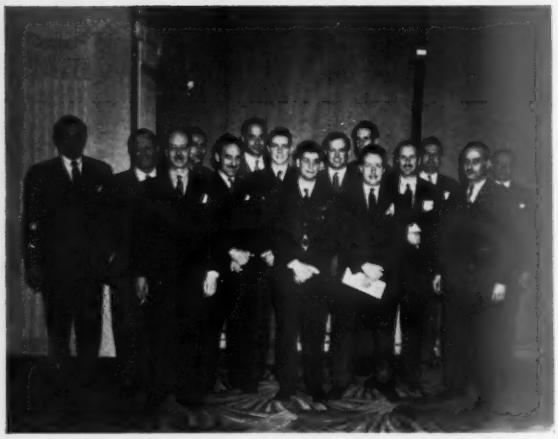
The FH-1 program typifies, to some extent, the problems met in all inlet design and, in particular, illustrates the characteristics of a wing installation.

For comparison, all inlets have been classified by Mr. Blatz into five generally basic types: wing inlets; nose and annular inlets; scoops, and flush inlets. (See Fig. 2.)

Advantages of the wing inlet type are: (1) Excellent recoveries may be obtained through a satisfactory range of angles of attack; (2) critical Mach Numbers can be made as high as the basic wing; (3) boundary-layer removal is relatively easy; (4) the fuselage remains uncluttered by ducts; and (5) practically no form drag is added to the plane.

Against these advantages are the following penalities: (1) Wing structure is complicated; (2) unless engines are installed in the wing root, resulting bends in the duct may lead to high losses.

The nose installation represents the optimum insofar as inlet aerodynamic characteristics are concerned. It has the advantage of being free of boundary layer effects. Except for angle of attack, there are no flow complications involved and excellent recoveries are obtained, and very high critical Mach Numbers may be obtained.



Delegation of Canadian members from the Toronto Section attending the meeting pause with I. A. S. staff members for an informal photograph.

The major disadvantage lies in the difficulty of installation in a fuselage which may result in the following penalties: (1) The duct must be excessively long and usually of an undesirable shape that leads to excessive weight and complications; (2) duct losses are high and tend to offset the advantages of forward location insofar as pressure recovery is concerned; (3) vision is restricted, since it requires a wider nose and a more aft location for the cockpit; (4) it compromises the installation of such items as armament and radar equipment.

All these disadvantages disappear in a nacelle installation (to which the preliminary design engineer may object because of the higher drag), and in that case the nose inlet is ideal.

The annular inlet is a variation of the nose type which eliminates many of the latter's disadvantages. The advantages are: (1) Good recoveries and high critical Mach Numbers may be attained; (2) boundary-layer flow offers little trouble; (3) visibility may be improved over the nose inlet; and (4) equipment may be carried in the nose.

However, it still has the basic disadvantage of long and complicated ducts, with accompanying structural and aerodynamic penalties.

In general, the external scoop is poor aerodynamically but from a design standpoint it is usually the lightest and least compromising to install. In most cases, however, such advantages are more than offset by increase in form drag, low critical Mach Numbers, and high duct losses.

The flush inlet was developed with the idea of eliminating some of the disadvantages of the external scoop while retaining low weight and structural simplicity.

Besides its relatively simple installation problems, flush ducts have low form drag and relatively straightforward ducts. However, like the scoop, it is often on the region of thickened boundary layer and superstream velocities and therefore subject to attendant losses in recovery and critical Mach Number.

While there will continue to be applications of all five types of air inlets, those that possess aerodynamic advantages, even at the cost of structural complication, will be most favored in high-speed turbojet aircraft. This means primarily the nose and annular inlet and possibly the wing inlet.

Because nacelles represent an increasingly important field of turbojet application, current trends in nacelle design were included in the talk. The biggest bugbear in nacelle design is wing-nacelle interference, not air induction, and in most turbojet installations the problem is to achieve high critical Mach Numbers.

Herbert C. Towle, Jr., Republic Aviation Thermodynamicist, in the third paper of the session, discussed the original design considerations for turbojet exhaust systems and Republic Aviation's approach to the engineering problems involved during development of its P-84 Thunderjet fighter.

Three main problems were covered: (1) protection of fuselage structure from intense heat of the jet; (2) adequate flexibility in the tailpipe to accommodate fuselage deflections; and (3) engine performance as affected by minute changes in jet nozzle diameter.

The fuselage structure was protected by cooling air that flowed between a stainless-steel shroud and the hot surfaces of the TG-180 power plant. No other insulation was used for the engine, tailcone, tailpipe, or shroud.

Besides its lighter weight, a shroud has other advantages that should not be overlooked. The cooling air, for instance, keeps the tailpipe slightly cooler than the exhaust gas, thereby increasing the service life of the pipe over what would be obtained if the heat in the pipe were confined by an insulating blanket. Moreover, some blankets have a tendency to absorb oil from one source or another, and this, along with any binder used in the blanket construction, is driven off when the engine is first run up. Serious fires also may result if a blanket becomes saturated with fuel because of a small leak in a tailpipe fitting.

The second problem, that of tailpipe mounting provisions, resulted from the fact the pipe is too long and heavy to be cantilevered from the engine tailcone and must be supported from the airplane structure. It is necessary to make a flexible connection between the pipe and cone. In the P-84, the normal tension loads in the pipe are carried through four pins and load-distributing straps, with the seal made by means of a Cook Electric bellows. Clearance is allowed in the pin bearings so that the pipe can bend sufficiently to allow for maximum fuselage deflections.

While it functions satisfactorily in the P-84, the design is not perfect, since it may concentrate a tension load of as high as 5,000 lbs. on one or two pins, introducing an unsymmetrical load into the tailcone. Mr. Towle said it is believed that additional benefits would be offered by a ball and socket joint if weight and expense penalties could be overcome.

Solution to the problem of the jet nozzle was arrived at by the use of a set of inserts with different curva-

tures rather than by trimming the tailpipe itself. These inserts fit inside a joggled retainer and are held in place by two stainless-steel screws. Loss of thrust caused by these inserts is far less than the limit of accuracy of present measuring devices.

The final talk of the Afternoon Session, presented by F. H. Sharp, Assistant Project Engineer of Consolidated Vultee, recommended a remote-mounted accessory system to relieve congestion in the turbojet powerplant nacelle.

To accomplish this, an auxiliary power unit, in conjunction with bleed air from the turbojet engines, drives all the continuous and semicontinuous duty accessories through the medium of low-pressure, high-flow air.

The proposed system is applied to the design of a large jet-powered flying boat.

Numerous at-anchor and in-flight functions would be performed by an air-driven accessory system. To accomplish these functions, the primary need is some device for producing compressed air at the pressures and flow rates required for operation of the other equipment. The gas-turbine type of auxiliary power appears ideally suited to this purpose, particularly a type that produces its horsepower output directly in the form of compressed air. The installed weight of the auxiliary power units should not exceed 100 lbs. for each unit.

The equipment required for a remote-mounted accessory system proposed for the type of plane suggested includes two gas-turbine auxiliary power units of 75 hp. each, nominal rating; air motor or expansion turbine-starters for the engines of approximately 50 hp. each with a unit weight not in excess of 30 lbs., including clutch and reduction gearing; two large generators or alternators, which, because of their size, must be mounted remotely with relation to the turbojets and driven by an air motor or expansion turbine unit mounted directly on each alternator.

The system is equally applicable to the prop-turbine-powered aircraft, since compressor bleed from the main engines is available for operating continuous-duty equipment just as it is in the turbojet.

To realize the greatest gains, the system must be completely integrated. Each duct must serve as many units as possible, and maximum utilization must be obtained from each unit.

No complete air-driven accessory system has yet been installed, but development and work are bound to bring one into being sooner or later.

Performance Possibilities of Aircraft Engines Utilizing Gas Turbines

by

Dr. Richard P. Krebs

THE EVENING SESSION was given over to the discussion of four types of aircraft propulsion systems. In introducing the speakers of the evening, Abe Silverstein said that the members of the N.A.C.A. Flight Propulsion Research Laboratory who gave the talks had taken a wide view of the potentialities of each of the engines and, in their analyses, had attempted to predict the performance of the propulsion systems when the present-day mechanical and thermal limitations and the inefficiencies of the components had been considerably surmounted.

The first talk of the evening was a discussion on the four-stroke spark ignition compound engine by LeRoy V. Humble. Mr. Humble defined the compound engine as a combination of a conventional four-stroke spark ignition engine, together with a compressor and a turbine. The data from the analysis was presented in terms of mean effective pressure (M.E.P.) representative of engine and component powers, specific fuel consumption, and specific weight. The effect of compression ratio, the ratio of the exhaust pressure to the manifold pressure of the reciprocating engine p_e/p_m, improved fuels, and changes in component efficiencies on engine performance were evaluated. For the analysis it was assumed that the theoretically correct fuel-air ratio was used, the turbine inlet temperature was limited to 1,800°F., and the flight conditions were 400 m.p.h. at an altitude of 30,000 ft. Turbine and compressor efficiencies were assumed to be 85 per cent.

The M.E.P. of the reciprocating component decreases, the turbine M.E.P. increases, and the compressor M.E.P. decreases as the ratio p_e/p_m increases. The maximum net M.E.P. for the engine for a compression ratio of 6 occurs at a value of p_e/p_m of about 0.8. This maximum was about 8 per cent more than for a fully turbosupercharged engine and about 18 per cent more than for an all-geared system without turbine.

The maximum knock-limited net M.E.P. increased more than three times when the compression ratio was lowered from 10 to 4 and occurred at values of p_e/p_m between 1.0 and 0.6. The maximum net M.E.P. was increased 6 per cent by increasing the reciprocating engine efficiency from 85 to 95 per cent, was increased $7^1/_2$ per cent by increasing the turbine and compressor efficiencies 10 per cent, and was increased 40 per cent by the use of fuel that would permit a 50 per cent increase in knock-limited manifold pressure.

Substantial reduction in fuel consumption can be obtained by compounding. For a range of compression ratios the minimum specific fuel consumption occurs at values of p_e/p_m slightly greater than 1.0, while maximum power occurs at values of p_e/p_m less than 1.0. In the remainder of the discussion the value of p_e/p_m is held fixed at a compromised value of 1.0. The specific fuel consumption increases from 0.31 to 0.37 lb. per hp.-hr. when the compression ratio is decreased from 10 to 4, decreases 5 to 8 per cent for a 5 per cent increase in reciprocating engine efficiency, and decreases 5 per cent for a 10 per cent increase in compressor and turbine efficiencies. No appreciable effect on the specific fuel consumption can be obtained by use of improved fuels.

The specific weight is doubled by an increase in compression ratio from 4 to 10 and is reduced 12 to

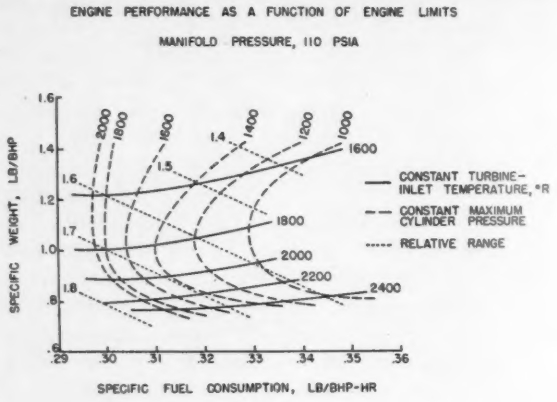

ENGINE PERFORMANCE AS A FUNCTION OF ENGINE LIMITS
MANIFOLD PRESSURE, 110 PSIA
SPECIFIC WEIGHT, LB/BHP
SPECIFIC FUEL CONSUMPTION, LB/BHP-HR
CONSTANT TURBINE-INLET TEMPERATURE, °R
CONSTANT MAXIMUM CYLINDER PRESSURE
RELATIVE RANGE

FIG. 3.

15 per cent when the allowable manifold pressure is increased 50 per cent. It is seen that any increase in specific fuel consumption resulting from an increase in compression ratio is obtained at the expense of the considerable increase in specific weight. A given decrease in fuel consumption is obtained with less weight penalty with higher grade fuels.

Relative range calculations were made in comparison to the range of an aircraft powered with a conventional reciprocating engine having a specific weight of 2 lbs. per hp. and a specific fuel consumption of 0.46 lb. per hp.-hr. Improved fuel grades increased the range. Negligible gains in ultimate range result from decreasing the compression ratio below 6. However, a reduction in compression ratio does result in gains in pay load for a fixed range.

The second talk, presented by A. E. Biermann, was on the two-stroke, compression-ignition compound engine. Previous analyses of the lightly compounded form of this engine have indicated marginal advantages because of excessive weight. Since the reciprocating engine is much heavier per unit horsepower relative to the gas-turbine component, it is advantageous to go to high degrees of compounding, thereby doing as much work in the turbine and as little work in the reciprocating engine as is compatible with the limits of pressure and temperature. The two-stroke cycle, compression-ignition engine has certain unique characteristics especially suitable for a highly compounded engine: absence of fuel knock and pre-ignition problems, feasiblity of operation at lean fuel-air mixtures, high air-handling capacity, and the absence of poppet valves. Mr. Biermann stated that the purpose of his analysis was to investigate the potentialities of this engine when the degree of compounding was increased and when engine limits and component efficiencies were varied.

Low specific weights are obtainable in the compound engine by increasing the degree of compounding—that is, by raising the manifold and exhaust pressures and at the same time decreasing the compression ratio and fuel-air ratio so that permissible values of cylinder pressure and turbine inlet temperature are maintained. The manifold pressure was used as being indicative of the amount of compounding. As the manifold pressure is increased, the airflow through the reciprocating engine and the specific air consumption are both increased. The relative rates of rise of these two factors determine the shape of the specific output curve. Under the assumptions made, the specific output becomes a maximum at a manifold pressure of about 110 lbs. per sq. in. The specific weight becomes a minimum at a manifold pressure of about 70 lbs. per sq. in. An increase in the degree of compounding initially causes the fuel consumption to decrease. In general, increasing the engine temperature and pressure limits moves the position of the optimum point from a fuel consumption and specific weight standpoint to a higher manifold pressure.

The specific fuel consumption is practically independent of compressor or reciprocating engine efficiency. However, the specific weight decreases with an increase in these efficiencies. A change in turbine efficiency from 70 to 90 per cent decreases the fuel consumption about 21 per cent and decreases the specific weight 13 per cent.

The effect of changes in the pressure and temperature limits on the specific weight, specific fuel consumption, and range is shown in Fig. 3. In this figure, as cylinder pressures increase engine compression ratio and mixture strength both increase. As turbine inlet temperatures increase, the mixture strength increases and the compression ratio decreases. Increasing the cylinder pressure primarily affects only the fuel consumption of the engine. Increasing the turbine inlet temperature generally has its most important effect on the specific weight.

Mr. Biermann concluded his talk with some specific values calculated for the engine. The overall pressure ratio of the complete engine at a cylinder pressure of 2,000 lbs. per sq.in. is greater than 450:1. With a temperature of 2,400°F. and a pressure of 2,000 lbs. sq.in., the overall engine delivers 4.1 hp. per cu.in. of cylinder displacement. Such figures indicate the possibility of a low specific fuel consumption and low specific weight.

The best airplane performance is obtained with an engine that operates at high pressures and temperatures, as may be seen at the lower left corner of Fig. 3. With a temperature- and pressure-limited engine there are a number of combinations of specific weights and specific fuel consumptions that would result in the same engine merit. For example, the same airplane range can be obtained with a specific weight of 1.2 and a specific fuel consumption of 0.30, corresponding to a cylinder pressure of 2,000 lbs. per sq.in. and a turbine-inlet temperature of 1,600°R., as is obtained with a specific weight of 0.8 and a specific fuel consumption of 0.34, corresponding to a cylinder pressure of 1,000 lbs. per sq.in. and a turbine inlet temperature of 2,400°R. Consequently, the difficulty of operating with high cylinder pressures must be weighed against the difficulty of operating with high turbine tempera-

tures. Fig. 3 also indicates that the maximum range is obtained with a turbine inlet temperature of approximately 2,100°R. regardless of the cylinder pressure.

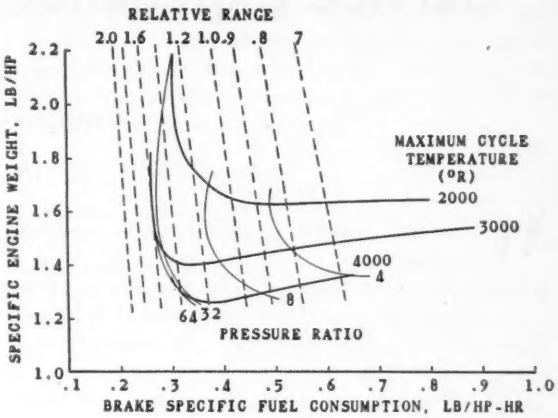
In the third talk, given by Robert O. Bullock, the changes in specific fuel consumption and maximum energy output from the values for the ideal cycle occasioned by the use of a real gas instead of an ideal fluid, introduction of component inefficiencies, and the effect of turbine blade cooling were presented for the turbopropeller engines. In the analysis, it was assumed that the pressure ratios across the compressor and turbine were equal.

Mr. Bullock first showed the familiar result that in the ideal cycle continually increasing the pressure causes a continual decrease in the specific fuel consumption. When real gases are considered, it is found that the change in gas properties accompanies changes in temperature and that composition will cause the specific fuel consumption at a given pressure ratio to be greater for real gases than for the corresponding perfect gas. At a pressure ratio of 50:1, the specific fuel consumption for 4,000, 3,000, and 2,000°R. are, respectively, 0.234, 0.211, and 0.202; whereas, the corresponding specific fuel consumption for the perfect ideal gas was 0.200.

When inefficiencies of the compressor, turbine, and combustion process are considered, marked changes in the relation between specific fuel consumption and pressure ratio appear. As the pressure ratio is increased for a given turbine inlet temperature, the relative quantity of fuel input diminishes, but an increased percentage of the fuel input supplies the energy degraded by the inefficiency of the component. The result is that for each turbine inlet temperature there is a minimum specific fuel consumption. The higher the permissible turbine inlet temperature, the lower is the minimum specific fuel consumption and the higher becomes the permissible pressure ratios. The maximum energy output of the cycle occurs at a lower pressure ratio than that from maximum economy.

The introduction of turbine blade cooling further increases the specific fuel consumption. The minimum specific fuel consumption of 0.327 for the 3,000°R. turbine-inlet temperatures occurs at a pressure ratio of approximately 60:1; with no cooling, the minimum specific fuel consumption was 0.289 at the same pressure ratio. Although a significant degradation of energy resulted from the cooling process, it was by no means sufficient to overcome the accrued benefits in economy offered by high turbine inlet temperatures. Increasing the turbine inlet temperature from 2,000° to 3,000° and 4,000°R. increased the specific power from 112 to 284 and 588 hp. per lb. air per sec., respectively. The specific fuel consumption at maximum power was reduced from 0.496 to 0.374 and 0.321, respectively.

The gains in fuel economy and specific power by going to higher temperatures and pressures must be tempered by a consideration of the change in specific weight of the power plants. The relation between the specific weight and the specific fuel consumption is



RELATIVE RANGE OF LIQUID-COOLED GAS-TURBINE-PROPELLER ENGINE

FIG. 4.

shown in Fig. 4. A significant decrease in engine weight per horsepower accompanies an increase in turbine-inlet temperature for a given pressure ratio. With a fixed turbine inlet temperature the specific weight is nearly constant over a wide range of pressure ratios and specific fuel consumption. As the pressure ratio approaches the value for the minimum specific fuel consumption, the specific weight increases rapidly. Ultimate range curves for a flight speed of 400 m.p.h.. and an altitude of 30,000 ft. are shown on Fig. 4. The range line of unity represents the estimated range of the best reciprocating engine available today. A large increase in range at 30,000 ft. is offered by the use of high cycle pressure ratios and a turbine inlet temperature of at least 3,000°R. Because of the apparent effects of disassociation, the calculated maximum range for turbine inlet temperatures of 4,000°R. does not equal that for 3,000°R.

The final paper of the evening was on the turbojet engine, by Reece V. Hensley. The discussion centered around the improvement of turbojet engine performance by means of increasing the compressor pressure ratio, turbine inlet temperature, air-handling capacity, and engine component efficiencies.

The losses in the compressor, burner, and turbine of today's turbojet engine bring increases of about 10 per cent in the specific fuel consumption for compressor pressure ratios up to 14 and about a 12 per cent loss in the maximum available thrust at an air speed of 500 m.p.h. and an altitude of 30,000 ft.

Considerable increase in the thrust per unit mass airflow are obtainable by increasing the turbine inlet temperature. An increase of turbine inlet temperature from 2,000 to 3,000°R. increases the maximum thrust by 60 per cent and increases the specific fuel consumption 12 per cent. The compressor pressure ratio at which maximum thrust is obtained increases with turbine inlet temperature.

(*Continued on page 36*)

Service Experience with Turbojet Engines

J. W. BAILEY*

General Motors Corporation

Introduction

While the subject of this paper is specifically "Service Experience with Turbojets," some digression from this subject has been made to present more clearly the importance of service difficulties in their relation to the experimental development of an engine of this type.

The turbojet engine, unlike its aircraft power-plant predecessors, has not had the advantage of many years of development and service experience which are normally required to produce a dependable engine having a practical service life between overhauls. The lessons learned in many years of development of conventional engines were applied to aircraft power plants of this general type, yet the development period of the turbojet engine dates back only slightly over 3 years in the United States. Several thousand hours of endurance running have been accomplished at Allison since 1945. In addition to this time on experimental test stands under the direction of development and design engineers, service flight time rapidly approaching 100,000 hours has been accomplished primarily in the P-80 airplane.

Importance of Turbojet

As the I-40 or J-33 engine was the first American turbojet engine built in production for a jet-propelled tactical aircraft, it is extremely important that we obtain the most out of the experience in service and in development. This is important because the improvements that can be made in efficiency, size, weight reduction, increased power, and economical manufacturing techniques may be applied to both turbojet and turboprop engines. It is obvious that the future power and speed requirements for military, as well as commercial, aircraft necessitate that the major portion of the aircraft-engine manufacturing and development facilities be directed toward the turbo-type engine. With the present limitations of experienced personnel and the reduction of development funds in a limited peacetime economy, it is necessary for the aircraft industry to take advantage of these past 3 years of experience in order for the United States to maintain its present position with regard to world air power.

Engine Development

For a better understanding and appreciation of the progress that has been made in the J-33 engine model, it must be compared with the reciprocating engine of similar tactical usage. For a comparative development period of 3 years, which for the V-1710 engine started in 1940 and for the J-33 engine started in 1945, approximately 30 per cent as much endurance running was accomplished on the J-33 engine as compared to the V-1710. During this period, the J-33 take-off power/weight ratio was increased in excess of 50 per cent, as compared to 22 per cent for the reciprocating engine. This serves to illustrate that the J-33 development, by a comparable engineering staff with regard to power and power/weight ratio, has progressed at a much higher rate and with less actual running time than a reciprocating engine under development during a war period. In both cases the increase in power was paralleled with an improvement in design with regard to durability. While it is realized that a reciprocating engine is somewhat more complex with regard to the number of highly stressed parts, the turbojet engine development has introduced new design, manufacturing, and service problems caused by centrifugal and thermal differential stresses and a multiplicity of other factors that would not normally be expected from previous conventional engine experience.

Further evidence of the development progress which is reflected by service experience is shown by the Model Test history (see Fig. 1) and take-off thrust ratings over the 3-year development period. The specified model test time was 50 hours during the early stages of production and was increased to 100 hours during the first year. Engines of the first model completed both the 50- and 100-hour test requirements. During the second year, an engine of the second model not only completed the 100-hour requirement but was reassembled for two 50-hour additional tests, making a total on one engine of 200 hours of model test operation. For the third engine model, the model test time was increased to 150 hours, which for many years has been standard for conventional engine types. One engine of the third model and two engines of the current production model completed this 150-hour test at considerably increased take-off ratings.

Engine Ratings and Performance

Rating and Control

The turbojet engine is peculiar and unlike conventional engines in its ratings and power control. The performance of such an engine as guaranteed by the engine manufacturer is based upon a minimum thrust and a maximum exhaust temperature corrected to standard sea-level conditions at a rated engine speed.

Presented at the Flight Propulsion Meeting, I.A.S., Cleveland, March 19, 1948.

* Head, Service Engineering Section, Allison Division.

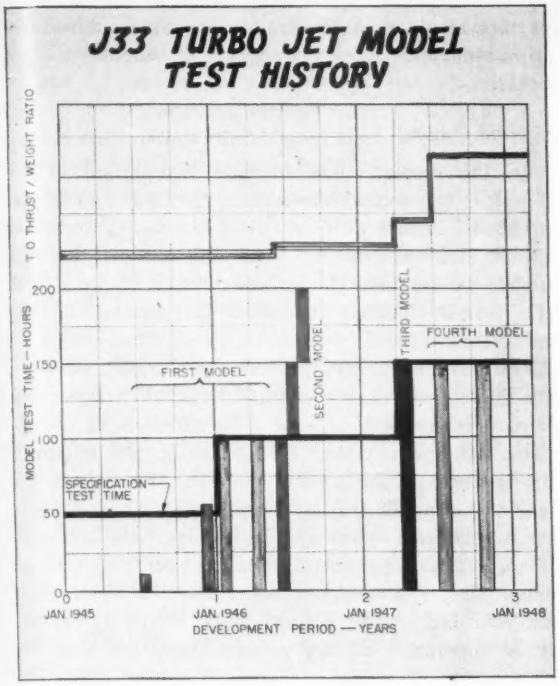


FIG. 1.

This means that for all temperatures below standard, with an engine control such as a governor which maintains only a maximum engine speed, powers in excess of those guaranteed can be, and are, obtained in service. Because the pilot has no control over the actual power output other than engine speed and exhaust temperature, the principal limitation of power available is the maximum amount of fuel available through the engine fuel system. For example, an engine having a guaranteed take-off rating of 4,600 lbs. at standard sea-level conditions may be accepted during production testing at a corrected value of 4,700 lbs. When this engine is flown at a temperature of −40° F., the pilot will be able to obtain approximately 6,500 lbs. of thrust for take-off at 100 per cent engine speed. The engine recieives no credit for this extra power, yet various components of the unit are subject to stresses considerably in excess of those possible under conditions for which the engine is guaranteed. (See Fig. 2.)

Production Engine Performance

During only the early production of the engine was there any noticeable variation in engine performance. This was due in part to lack of production experience required for control of those parts, such as the nozzle diaphragm, which have the greatest effect on performance. The establishment of a specific acceptance test tailpipe and nozzle combination—defined in the engine specification as to length of pipe, nozzle taper, and diameter—contributed to a standardization of performance evaluation. It should be pointed out that the turbojet engine acceptance is based on minimum values of thrust at specific speeds, exhaust temperature, and fuel consumption; therefore, any variation in performance is thrust *over* the guarantee at exhaust temperatures and fuel consumptions under the guarantee. In a sample of 100 production engines, the thrust variation averaged 4 per cent above the guarantee at exhaust temperatures averaging 35° F. below the maximum allowable.

Performance Vs. Service Time

Tests have shown that there is little or no appreciable performance loss in the engine due to service time. Service engines having accumulated over 100 hours of operation have been tested prior to overhaul and in every case have developed from 30 to 185 lbs. over the guaranteed thrust rating of the engine at exhaust temperature and fuel consumption values within the production acceptance limits. Model test experience has shown an average of one-fifth of the allowable depreciation in thrust at the end of 150 hours.

INSTALLATION PROBLEMS

Tail Pipe and Nozzle

Fortunately, the turbojet engine, because of its operational simplicity, is not so seriously affected by the installation as was experienced with reciprocating engines. The principal installation problems concern a selection of the proper tailpipe and jet nozzle combination, which under hot-day operation will not exceed the maximum engine exhaust temperature limit. The exhaust pipe and nozzle combination in the aircraft installation seldom conforms to the specifications of the engine manufacturer's production test requirement.

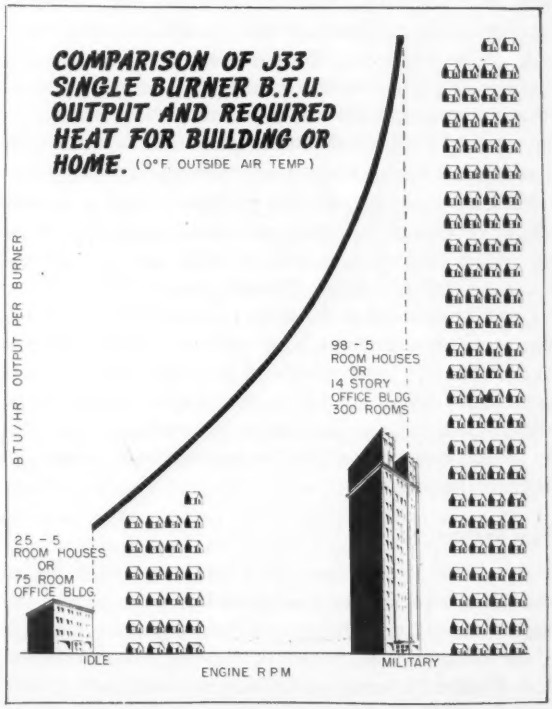

COMPARISON OF J33 SINGLE BURNER B.T.U. OUTPUT AND REQUIRED HEAT FOR BUILDING OR HOME. (0°F. OUTSIDE AIR TEMP.)
B T U / HR OUTPUT PER BURNER
98 - 5 ROOM HOUSES OR 14 STORY OFFICE BLDG 300 ROOMS
25 - 5 ROOM HOUSES OR 75 ROOM OFFICE BLDG
IDLE
ENGINE R P M
MILITARY

FIG. 2.

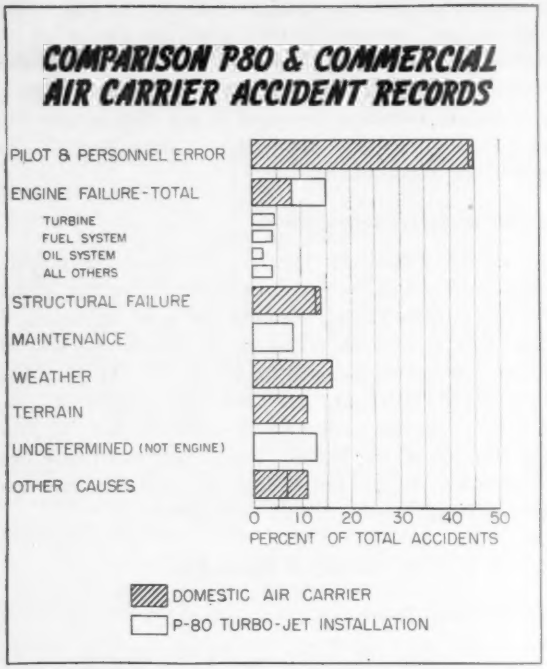


FIG. 3

The aircraft manufacturer therefore has the problem of selecting a nozzle diameter that in conjunction with the aircraft tailpipe will give a pressure drop equivalent to that obtained with the engine specification nozzle used while meeting guaranteed performance which provides an installation corrected exhaust temperature equal to that obtained during acceptance testing of the engine. Normally, this means that the available thrust in the airplane reflects the loss resulting from the airplane tailpipe. Experience has shown that production engine performance is closely enough controlled that a nominal aircraft tailpipe and nozzle combination can be selected which will not exceed the maximum limit on any engine of the particular model.

An important installation problem is that of mounting or properly supporting the aircraft tailpipe in order to ensure that excessive flight loads are not imposed on the engine structure. The tailpipe must be mounted in such a way that it is free to expand under operating temperature conditions and will not restrict engine expansion. It has been found desirable with tailpipes of considerable length to include a flexible joint between the aircraft tailpipe and the engine tail cone in order to avoid excessive loads under misalignment caused by aircraft deflection.

Fuel System

It has been found necessary in the turbojet engine installation to maintain a filtered fuel supply to the engine and to use extreme care in the ground handling of fuel servicing equipment, in that out of necessity the fuel system is sensitive to dirt accumulation. Dirt introduced through the aircraft fuel system can contribute to sticking of fuel controls and clogging of fuel nozzles, resulting in burner unbalance, uneven heat distribution, and serious warpage of engine components.

Ground Cooling

In the plenum chamber type installation of the double-entry compressor engine, ground cooling has presented certain problems that can cause, and have caused, service difficulty. Cooling air for the rear turbine bearing and the turbine wheel is obtained from the plenum chamber at a point just behind the rear compressor inlet. Tests have shown that under reduced plenum chamber pressures or no ram conditions, the cooling air that is normally ejected between the burners is reversed and heated air surrounding the airplane tailpipe and burner section of the engine is drawn through the cooling passage. Because of the lack of cooling air and the introduction of heated air to the bearing area by exhaust gas leakage, an overheating of the rear bearing and its housing occurs to such an extent that in several instances failures of the bearing and burning of the housing have actually resulted. It is imperative during ground operation that the plenum chamber and accessory doors be opened or removed in order to reduce the pressure drop across the turbine cooling fan. Operation even under these conditions is marginal and must be restricted to only short periods.

SERVICE EXPERIENCE

During the 3 years of operation of the J-33 engine in the P-80 airplane, flying time approaching 100,000 hours has been accomplished. Naturally, with a new airplane and engine combination of this type, this amount of flying time was not accomplished without difficulty. (See Fig. 3.)

Fuel System

The engine, as initially designed, incorporated aluminum external fuel system plumbing. Initial service and production experience indicated the need for replacement of this type of piping with flexible hose, because the large diameter rigid-tubing was difficult to align and install, was not consistently interchangeable in service as spare parts, and was susceptible to leakage because of failure at the flared tubing ends. The flexible hose plumbing has greatly improved the serviceability of turbojet engines in the field and at overhaul and has been practically trouble-free.

Controls used on the first four models consisted of an overspeed governor, an altitude-compensated relief valve, and a throttle valve. In the early stages, preliminary flight-test difficulties were encountered primarily with the engine governor. These troubles were corrected in production designs, but because of two accidents, possibly attributed to the engine governor, it was extremely difficult to obtain pilot acceptance of the reliability of the redesigned system. This early experience has had a definite lasting influence on the

present and future engine requirements, even though the corrected design has given excellent performance and has not experienced a failure that has caused loss of power either during take-off or flight.

These early failures established the precedent of the emergency fuel system now included as a standard requirement for all turbojet engine installations as an airplane supplied electrically driven pump and control system. These airplane systems have had no altitude compensation and therefore have been limited to take-off, initial climb, and landing conditions, plus supplying the necessary fuel pressure for engine starting. In no definitely known instance would the loss of airplane or personnel have been avoided by the complication of altitude compensation to this system, yet the service and pilot psychology established by early failures of a now obsolete control plus a cautious approach to the problem of providing maximum safety have imposed a difficult requirement on the engine supplied emergency fuel system for current, as well as future, turbo-type engines.

Present and future production engine specifications stipulate that the duplicate or emergency fuel system must be included as part of the engine fuel system and must be capable of operating the engine during altitude flight, as well as take-off and landing. The new controls must, in addition to providing an automatic emergency system, limit acceleration and deceleration in order to eliminate the possibility of "flame blowout" or exhaust temperature over specified limits. Provisions have been made for automatic starting, which is not only a means of utilizing the fuel pressure from two phases of the engine dual fuel pump but also furnishes a starting procedure not affected by pilot technique.

Burner Blowout

"Burner blowout" and complete loss of fire has occurred in only a small number of instances in actual service operation. It has been experienced with somewhat higher frequency during experimental flight test, for the most part caused by deliberate mishandling of the throttle. Normally, this condition occurs at high altitude as a result of too rapid acceleration or deceleration to fuel pressure values below the engine speed requirements to sustain flight. When blowout occurs, altitude starting can consistently be accomplished by following the normal ground start procedure, with the exception that windmilling is used to sustain engine speed to normal cranking values and, on current service engines, ignition is limited to altitudes of approximately 20,000 ft.

Hot Starts

"Hot starts," in most instances a function of pilot technique, have occurred frequently in service and seriously affect engine life by excessive distortion of certain parts of the burner section. Until considerable service experience was obtained as to the damage caused by this condition, quantities of engines were sent to overhaul because they have been subjected to three "hot starts." This limitation was then increased to ten "hot starts" and at the present time, engine removal, because of this abuse, is based upon a thorough inspection of the engine parts subject to the most distress from this condition.

Turbine Wheel

Several serious service failures and a small number on test stands occurred early in the history of this engine. Immediately, a combined program was initiated in conjunction with the General Electric Company to determine not only the cause but to develop improved methods of segregating good from bad forgings, to improve inspection methods, and to investigate completely the entire processing procedure from the basic alloy to the finished wheel.

Preliminary investigation indicated that each of the failures had certain features in common.

(A) Total operating time on each of the wheels with only one exception (15 hours) was less than 10 hours.

(B) The forgings from which each of the failed wheels had been fabricated was from a common bottom ingot position.

(C) The engine governors that had been designed to prevent engine overspeed were set 300 to 400 r.p.m. over the normal military rated speed, and by their own admission it was impossible for pilots during take-off to avoid engine overspeed, which was also common during ground run-up.

The two major sources of operating stress consist of: (1) centrifugal stress caused by rotation of the wheel mass; and (2) thermal differential stresses that result from the temperature difference existing between the periphery and the central portion and also between the front and rear face of the wheel.

All of these stresses are proportional, in varying degrees, to the engine r.p.m. The total of all these stresses results in a stress vs. engine speed curve that is sharply rising at higher speeds, as illustrated in Fig. 4. At the same time, the physical strength of the wheel material is reduced with engine r.p.m. by reason of the increase of temperature with rotor speed.

The steepness of the two curves is such that the operating margin (which is represented by the vertical distance between the two curves) is satisfactory at rated speed, whereas only a few hundred r.p.m. higher will reduce the spread between the existing stresses and the strength of the wheel material to such value that wheel failure may be impending. From this curve it is obvious that, because of the multiplicity of adverse factors that arise as speeds are increased in excess of military r.p.m., the operating margin decreases much more rapidly than would normally be expected from previous experience with reciprocating engines and other rotating machines.

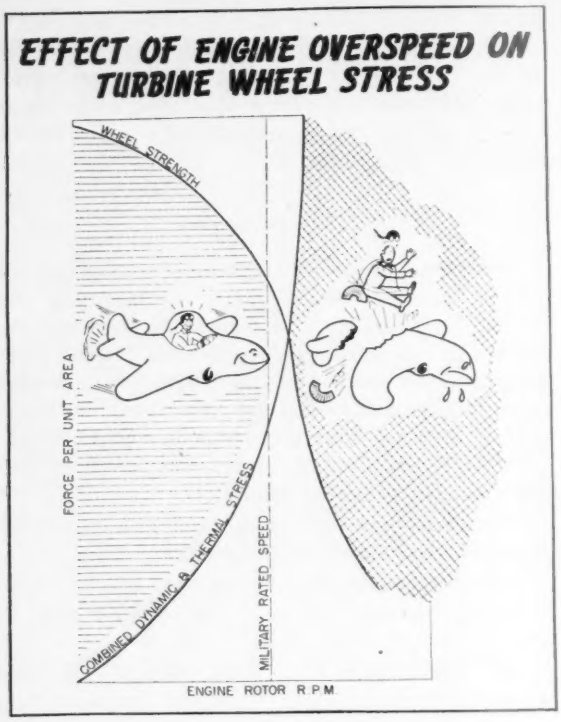

EFFECT OF ENGINE OVERSPEED ON TURBINE WHEEL STRESS
WHEEL STRENGTH
FORCE PER UNIT AREA
COMBINED DYNAMIC & THERMAL STRESS
MILITARY RATED SPEED
ENGINE ROTOR R.P.M.

FIG. 4.

By an investigation of service failures, an analysis of the results of spin pit burst test of many wheel forgings, and a review of the complete processing, including the verification of inspection methods such as supersonic and penetrant oil, a general improvement of the turbine wheel assembly was realized. The preproduction cold wheel spin test accomplished both in the unbucketed and the bucketed conditions were increased in speed. These spin tests imposed centrifugal stresses approximately 10 to 15 per cent over the calculated combined thermal and centrifugal stresses imposed at the hub under engine running conditions at take-off speed. These overspeeds, preceded and followed by sonic and penetrant oil inspections, served not only as a method of segregating good from bad forgings but also provided residual compressive stress at the wheel hub. This entire investigation brought about by service experience disclosed the magnitude of new problems to be solved in forging the mass of material of the turbine wheel, the control of consistency of material quality throughout the ingot, as well as the general improvement of the ingot quality. In addition to the improvement of general quality in material in the wheel forging, any questionable wheel assemblies from bottom ingot positions were removed from service engines as possibly a somewhat extravagant safeguard against future failures. Previous experience on highly stressed parts was also applied in the machining of this critical part in order to avoid the introduction of surface stress cracks. Since this program has been initiated and the engine governor set to prevent overspeed in the field, there have been no failures.

Turbine Blades

Turbine blades have presented two service problems. One involved, primarily, the assembly, fit, and securing method of the blade in the wheel assembly. In service, considerable quantities of engines were sent to overhaul only because the blades had moved forward or aft in excess of a specified limit. Various attempts at improvement of the peening originally used to secure the blade were unsuccessful, and it was not until a positive pin-locking method was developed to position the blade definitely that the difficulty was eliminated. By adoption of this feature it was possible to simplify greatly the assembly by means of changing the interference fit between the wheel "dovetail" and the base of the blade. This also simplified the spare parts supply problem by reducing the number of selective blade "dovetail" sizes required under the old procedure to select for proper fit at assembly. This design change was so developed that by a relatively simple rework it has been applied retroactively to all older engines at engine overhaul.

The second difficulty with blades has been that of failure in an area approximately one-third of the blade length from the tip. While improvement of the configuration of the part was incorporated as a design correction, the pinning method of securing the blade to the wheel, with its accompanying change in fit, has eliminated all failures by a dampening effect on blade vibration. It is interesting to note that, while blade failure during flight causes a noticeable vibration, the broken part is normally ejected out the tailpipe, and the airplane can safely return to base under reduced power. There has been no evidence that blade failures ever contributed to turbine wheel difficulties.

Burner Liners

The buckling and cracking of combustion chamber liners, while not serious with regard to flight safety, has been a problem in service on earlier models of this engine type. Design changes involving the support of the liner, giving it freedom to expand under temperature rather than being confined, increase in liner wall thickness, and manufacturing refinements have, in general, increased the service life from 25 to approximately 200 hours. A further modification that extends the liner to a postion closer to the nozzle diaphragm has practically eliminated localized hot spots in the outer burner assemblies, thereby greatly improving the life expectancy of the ring and tube assembly. These improvements have shown gratifying results to date and are now being incorporated in earlier type engines as a means of extending their overhaul time limitation to 200 hours. Considerable education has been necessary for inspection personnel to appreciate that minor buckling and cracking of liners has no serious detrimental effect on engine performance or liner durability, and the liners are not expected to be in the original condition at the end of 150 to 200 hours of engine operation.

Other parts of the combustion section such as the burner domes and nozzle diaphragm have given excellent service performance when not subjected to excessive temperatures as caused by "hot starts" and other mishandling. Warpage of such parts as the nozzle diaphragm must be expected, but such conditions do not detract from the operation or safety of the particular part. The same applies to the exhaust cone, which, like the nozzle diaphragm, suffers the most distress from engine mishandling. Continued improvement is being made by changes of material, method of support, and uniform heat distribution which will contribute materially to the more satisfactory operation of these parts subject to extreme temperature. It is on these assembles that the greatest degree of design ingenuity and improved materials will be required to extend further the overhaul life.

Illustrative of the problems encountered in the improvement of the serviceability of assemblies of the combustion section, such as the burner liner, is the analogy of the output of a single burner of a typical turbojet engine and the heating system of a commercial office building. At military power, the B.t.u. output of a single burner fabricated principally of sheet metal is equivalent to that of the brick-lined fire box of the steam plant required to heat a 14-story modern office building of 300 rooms at an outside air temperature of 0° F.

Ignition and Electrical Systems

The requirements of the ignition system for turbojet engines are relatively simple in that it must provide sufficient electrical energy at the spark plug only during the starting condition. Because of the remote possibility of burner blowout and the tactical usage in some installations where the engine must be started above 25,000 ft. altitude, starts present a more exacting requirement. Service experience has shown that the simple electrical system as included on past production models was satisfactory to provide ignition for ground starting and for altitudes up to approximately 20,000 ft. but that sufficient electrical energy was not available for starts above this altitude. Spark-plug fouling by excessive carbon accumulation on the electrodes during flight has been a specific problem now greatly alleviated by the design change of the plug which provides additional directed air blast through the plug shell. This specific difficulty was particularly hard to duplicate on endurance test stands with any consistency, and the corrective measures were the result of extensive service testing of experimental plugs in service activities.

Compressor Impeller

The second most serious failure with regard to engine damage has been that of compressor impeller blade breakage. The appearance of failures indicated rapid fatigue influenced by slight variation in material in that the failures were isolated to specific heats of the raw stock. As in the problems of the turbine wheel, the handling of the large mass of material of the wheel forging, the application and interpretation of known inspection methods for forgings of this size, and the stresses imposed by the rotational speeds and induced vibration brought about new problems in the control of the processing of such engine parts. It was apparent that only through the more uniform control of the raw material and fabrication processing that even isolated failures of this type could be completely eliminated.

Fire Hazards

J-33 engine installations operating on kerosene to date have been comparatively free from aircraft fires with the exception of cases of negligence on the part of maintenance crews. Again, improper starting techniques producing false starts and excessive fuel quantities introduced into the engine without combustion resulted in abnormal fuel leakage into the aircraft nacelle or fuselage. Many times when combustion is obtained, vapor from leakage fuel is ignited and an aircraft fire results. It is impossible to design the engine in such a way that under such conditions fuel will not drain from certain split lines that are impossible to seal because of high operating temperatures. For this reason it has been necessary that the aircraft manufacturers include scupper drains under such flanges to remove such fuel leakage from the compartment surrounding the engine.

Several instances of extreme fuel leakage during ground operations have occurred as a result of improper aircraft or engine fuel-line connection. This has caused extensive fire damage, the fuel having been ignited by electrical components in the plenum chamber or "backfire" of excessive fuel being introduced into the compressor inlet. From this experience and from known reversed airflow through the turbine bearing cooling air passages during all ground operation, it is apparent that such fuel is not ignited because of being drawn into the cooling air ducts in the vicinity of the turbine wheel and cooling fan.

Accident Record

The J-33-powered P-80, being the first operational jet fighter used by the U.S.A.F., has suffered somewhat from the "growing pains" of any new military airplane having the differences in flight characteristics especially with regard to take-off and landing. The net result has been that the early transition period experienced only slightly higher accident rates than conventional aircraft where previous pilot experience was the deciding factor in making the proper decisions at times of emergency. The accident record (Fig. 3) shows a frequency of pilot error comparable to commercial air-carrier records. In addition, approximately 50 per cent of the accidents caused by mechanical failure of the airplane or engine resulted from a combination of pilot judgment and the actual mechanical difficulty.

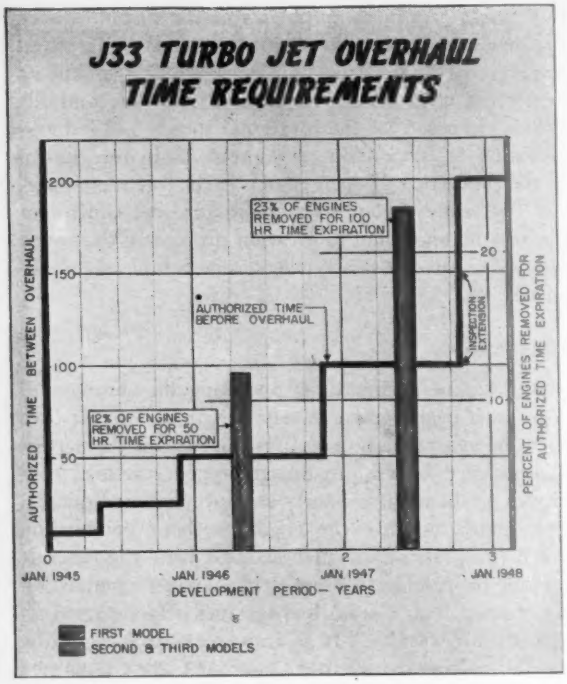


FIG. 5.

This record has greatly improved over the 3-year development and transition period primarily because more adequate training facilities and experience have been available to acquaint the pilots and maintenance crews with the problems of proper operation of jet-powered airplanes. The turbojet engine, in comparison with reciprocating types, is more sensitive to overstress because of overspeed and excessive temperatures and must therefore command better respect and appreciation of its limitations until its development has progressed to a point of more complete automatic control that will limit the possibility of engine mishandling.

CONCLUSIONS

Even with the difficulties that have been experienced and are to be expected in a new engine of this type, the turbojet engine has accomplished a gratifying service history, as shown by the increase in time between overhauls from 10 to 200 hours in the past 3 years (see Fig. 5). During the second year, 12 per cent of the engines of the first model sent to overhaul had completed the specified time expiration of 50 hours without failure. Twenty-three (23) per cent of the engines of the second and third models completed the 100-hour authorized time between overhauls during the third year. The turbojet engine has established an enviable record, which is representative of a sound basic design and the continued incorporation of design improvements under conditions of utmost cooperation from the U.S.A.F. Progress is only made by the full appreciation and utilization of service experience qualified by controlled development testing. There are still many problems to be solved with a never-ending requirement for increased power, less weight, and engine control complexity providing automatic actuation of all phases of the engine operation, which leaves a great deal to be done in the further improvement of the turbojet engine.

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(*Continued from page 29*)

An increase in air speed decreases the maximum values of thrust per unit airflow if the turbine inlet temperature is held fixed and also reduces the compressor pressure ratio at which maximum thrust occurs. The variation of the pressure ratio corresponding to maximum thrust with flight speed indicates the necessity for using an engine designed for the stipulated flight condition if maximum thrust is to be realized.

One of the primary requisites for high thrust per unit frontal area is the high air-handling capacity of the engine. Mr. Hensley pointed out that sea-level airflows as high as 25 lbs. per sec. per sq.ft. of frontal area should be possible. In general, it is possible to have as high a burner air-handling capacity as the compressor air-handling capacity for pressure ratios above 4 and flight speeds above 500 m.p.h. The turbine air-handling capacity is also greater than the compressor air-handling capacity for a turbine inlet temperature of 2,000°R. and the compressor pressure ratio and airspeed indicated.

The data on the ultimate range of a turbojet-powered aircraft were of particular interest and were presented as a range relative to the range of an aircraft powered by a conventional reciprocating engine. At a pressure ratio of 4 and a flight speed of 500 m.p.h., the best range is obtained at a turbine inlet temperature of 1,300°R. This range is 19 per cent greater than the range that would be possible at 2,000°R. and the same pressure ratio. Increasing the pressure ratio from 4 to 15 results in a 22 per cent increase in range, and the turbine inlet temperature for maximum range is increased from 1,300 to 1,800°R. For the latter combination of pressure ratio and turbine inlet temperature, the range is about equal to that of an aircraft powered by a reciprocating engine. The use of pressure ratios above 25 and turbine inlet temperatures above 2,000°R. do not result in significant improvements in range at 500 m.p.h.

Prediction of Load Distribution and Its Effect on Aerodynamic Characteristics at Subsonic Speeds for Wings of Arbitrary Plan Form

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Ames Aeronautical Laboratory, N.A.C.A.

Introduction

The present emphasis on flight in the transonic and supersonic speed ranges is directing interest to widely diversified plan forms. Ranges of sweep, aspect ratio, and taper ratio are being considered which extend far beyond those considered practical several years ago. The effect of wide variations in these parameters on the subsonic aerodynamic characteristics of wings is as yet largely unknown. The multiplicity of possible plan forms precludes an experimental investigation of each. As a result, considerable effort has been directed toward developing a theoretical method of predicting the loading over these wings of unusual plan form, since, once this loading has been determined, not only can structural loads be estimated but values of the various aerodynamic characteristics—such as lift-curve slope, aerodynamic center location, and induced drag—can also be found. The investigation of several theoretical methods for the prediction of loading on wings of arbitrary plan form, including the application of one of these methods to a wide range of plan forms, is the subject of this paper.

Comparison of Three Methods for Predicting Loading

Theory

The theoretical methods studied were those developed by Falkner, Weissinger, and Mutterperl. In each of these methods the wing is replaced by a distribution of vortices. The strength distribution of these vortices is fixed by the boundary condition, which requires that at particular points within the wing plan form the vertical velocities induced by these vortices produce no flow through the plane of the wing. The differences among the methods lie in differences in physical location of the vortices, disposition of the control points where the boundary condition is applied, and finally in the mathematical manipulation.

In Fig. 1 are compared the layout of vortices and control points for the methods. Falkner replaced the wing with a distribution of finite horseshoe vortices both spanwise and chordwise. He likewise distributed the control points both spanwise and chordwise. Hence, his method is classified as a lifting-surface method. The vortex and control-point distribution patterns are arbitrary, thus allowing application of the method to wings having irregular or curved plan forms. Random distribution of a sufficient number of vortices and control points should result in good accuracy, but generally it has been found that the total number required and, hence, the computing effort can be greatly eliminated by careful choice of their positions for different types of plan forms. For the simple swept wings bounded by straight leading and trailing edges, Falkner has recommended the particular pattern that was followed in our studies and which is shown in Fig. 1. In contrast to the Falkner lifting-surface method, both the Weissinger and Mutterperl methods are lifting-line methods—that is, the loading or chordwise vorticity is concentrated on the quarter-chord line, and a continuous sheet of trailing vortices is shed from this line. The control points are distributed along the three-quarter chord line. The Weissinger and Mutterperl methods differ in the spanwise location of the control points and in the mathematical development.

Since all three of these methods are extensions of simplified wing theory, they are subject to the same assumptions and limitations. First, it is assumed that the flow is potential with rear stagnation point at the trailing edge, which means that boundary-layer and separation effects are ignored. Second, the fluid is considered incompressible; however, later in this paper a method will be indicated for extending the results to higher subsonic Mach Numbers. Third, all vertical

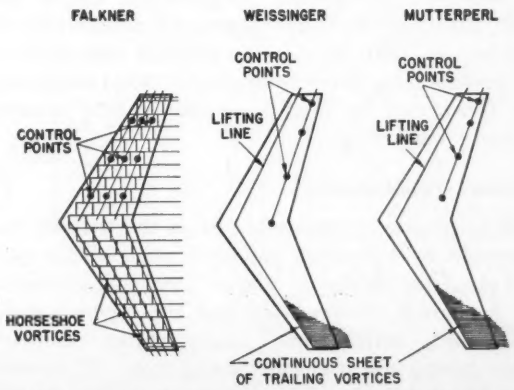

Fig. 1. Distribution of vortices and control points.

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* Aeronautical Research Scientist.

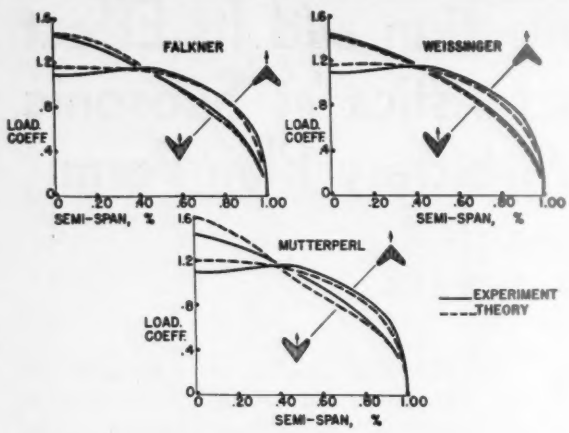

FIG. 2. Comparison of experimental and theoretical loadings.

EVALUATION OF METHODS

	FALKNER	WEISSINGER	MUTTERPERL
$dC_L/d\alpha$, AV. DEV.,	2 %	3 %	5 %
SPANWISE c.p., AV. DEV.	½ %	1 %	2½ %
LOAD ACCURACY	VERY GOOD	VERY GOOD	VARIABLE
OVERALL ACCURACY	VERY GOOD	GOOD	VARIABLE
TIME	30 HOURS	3 HOURS	28 HOURS

FIG. 3. Evaluation of theoretical methods.

displacements of the wing and vortex sheet are ignored, which requires that the lifting elements and control points on the wing and the trailing vortex sheet all lie in the same horizontal plane. Strictly speaking, this limits the analysis to uncambered, untwisted wings at zero angle of attack. However, in the application of these methods the angle-of-attack distribution along the chord is considered, even though the associated displacement has been ignored, so that wings having camber and twist and operating at moderate angles of attack can be handled. In general, it can be said that, although these assumptions and limitations should not be overlooked, they are an accepted part of nearly all unswept wing theories and no additional inaccuracies are introduced by their incorporation into theories covering swept wings.

Evaluation of Methods

In the course of this study each of the methods was examined by Van Dorn and DeYoung[1] for accuracy and ease of application. The accuracy was evaluated by comparing the predicted and the experimentally determined aerodynamic characteristics of five wings having sweep angles ranging from 45° forward to 45° back. By keeping an account of the time required to predict the wing characteristics, each method was also evaluated with regard to ease of application. Some results of this study are shown in Fig. 2, which compares the measured and predicted loading for the 45° swept-forward wing and the 45° sweptback wing. The agreement between experiment and theory for the 45° swept-forward wing was found to be indicative of the agreement for the swept-forward wings, and, similarly, that for the 45° sweptback wing was found to be indicative of the agreement for the sweptback wings. Both the Falkner and Weissinger methods were in good agreement with experiment. The Mutterperl method, while predicting with moderate accuracy the loading on the sweptback wings, did not give accuracy comparable to the other methods in the case of the swept-forward wings.

The accuracy of the three methods in predicing lift-curve slope and spanwise center of pressure, as well as loading for the five swept wings, is summarized in Fig. 3. With regard to both lift-curve slope and spanwise center of pressure, the Falkner method showed the least deviation from experiment, the Weissinger method slightly greater, and the Mutterperl method the greatest. With regard to overall accuracy, the Falkner method was judged to be excellent, the Weissinger method good, and the Mutterpel method uncertain.

The Weissinger method was found to be by far the most rapid, since the time required to find the loading for a given plan form was only 3 hours. In contrast 28 hours was required per solution for the Mutterperl method and 30 hours for the Falkner method.

On the basis of these results it was concluded that for a detailed study of given plan form, where a high degree of accuracy was desired and where ease of application assumed lesser importance, the Falkner method was best. Further investigation has shown that the Falkner method is also well suited to determination of chordwise loading, provided that boundary-layer effects are not significant. However, for a general study of a variety of plan forms the Weissinger method appeared best suited, since good accuracy could be had at a 90 per cent saving in computing time.

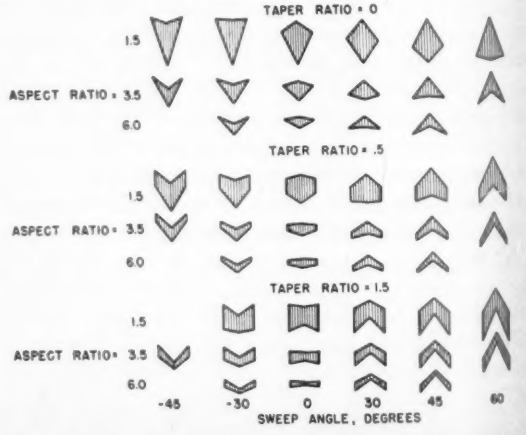

FIG. 4. Range of plan forms investigated by Weissinger method.

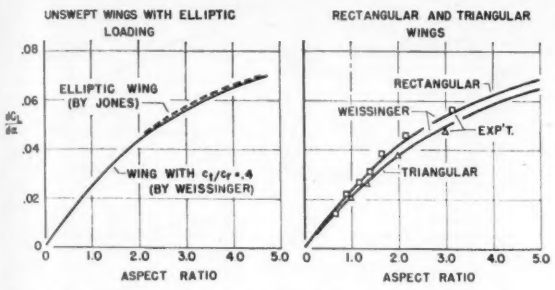

FIG. 5. Evaluation of Weissinger method for predicting lift-curve slopes on specific plan forms.

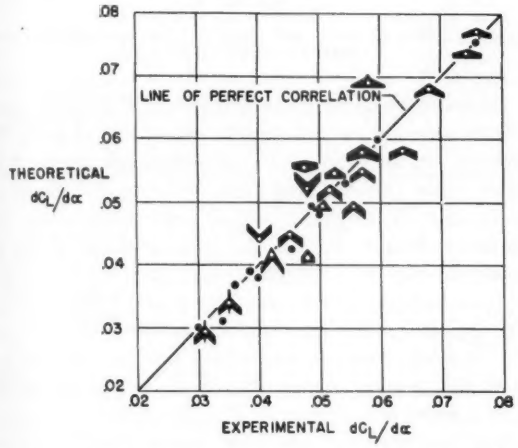

FIG. 6. Evaluation of Weissinger method for predicting lift-curve slopes on random plan forms.

APPLICATION OF WEISSINGER METHOD TO A WIDE RANGE OF PLAN FORMS

Scope of Study

Accordingly, the Weissinger method has been utilized to investigate the loading and associated aerodynamic characteristics of a wide range of plan forms. Fig. 4 pictures the range covered but does not indicate the number of plan forms considered. Actually, the characteristics of about 200 wings were calculated. The general range of variables included sweep of from 45° forward to 60° back, aspect ratios of 1.5 to 8.0, and taper ratios of 0 to 1.5. The structural feasibility of the various shapes was used as a rough guide in selecting the limiting values of the geometric parameters.

The results of this investigation have been published recently as a Technical Note by John DeYoung.[2] Charts published in this report allow a rapid and simple determination of the most important aerodynamic characteristics of any wing having a plan form falling within the range of this study. Aerodynamic characteristics that can be read directly from these charts include the span loading coefficients, spanwise center of pressure, lift-curve slope, and aerodynamic center. These parameters are given as a function of sweep for families of aspect ratio and for various taper ratios. Sufficient values of aspect ratio and taper ratio were chosen to allow rapid and accurate interpolation. The design charts as such will not be discussed in this paper, but the accuracy of the results as obtained from these charts and some of the more interesting effects of plan form on the aerodynamic characteristics will be examined in some detail.

Correlation of Measured and Predicted Results

Since there are little loading data available, the correlation of measured and predicted results is largely restricted to lift-curve slope and aerodynamic-center location as determined from wind-tunnel-balance measurements. For the plan forms shown in Fig. 3, the Weissinger method has demonstrated its ability to give good predictions of the loading. The method has produced equally accurate loading for a triangular wing of aspect ratio 2. From this it can be inferred that the Weissinger method should give good prediction of loadings for the range of wings investigated.

An evaluation of the accuracy of the Weissinger method in predicting lift-curve slope on specific types of plan forms is shown on Fig. 5. On the left is compared the variation of lift-curve slope with aspect ratio for elliptic wings as determined by the Jones effective-edge-velocity method and for wings having 0.4 taper ratio as predicted by the Weissinger method. It is generally considered that the values predicted using the Jones effective-edge-velocity method are accurate for elliptic wings. The 0.4 taper ratio wing was chosen for comparison, since it shows nearly elliptic loading. The agreement between these two methods is extremely good. Although not shown here, the variation of lift-curve slope with aspect ratio as predicted by Krienes also shows good agreement with Weissinger results.

On the right half of Fig. 5 are shown the variations of lift-curve slope with aspect ratio for triangular wings and unswept rectangular wings as predicted by Weissinger and as measured experimentally. Again the agreement is excellent, even at extremely low aspect ratios where there might be some question as to the accuracy of a lifting-line method.

In Fig. 6 are correlated the theoretical and experimental values of lift-curve slope for a number of ran-

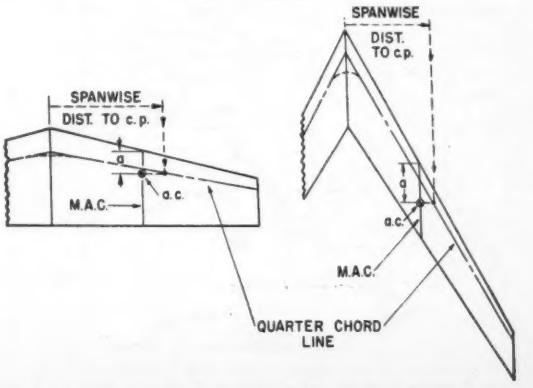

FIG. 7 Determination of aerodynamic center location.

dom plan forms. Where sufficient clearance between points existed, the wing plan forms have been superimposed. Included in this correlation are triangular wings, highly sweptback wings, swept-forward wings, and wings with inverse taper. Deviation from the 45° line indicates the error of correlation. On the average this deviation is less than 3 per cent.

The Weissinger method as originally proposed was not intended to give the aerodynamic-center location. However, as shown in Fig. 7, it may be used to give a good approximation to the position of the aerodynamic center for wings having moderate to great angles of sweep. The Weissinger method gives directly the spanwise loading and, hence, the spanwise center-of-pressure location. Since the loading is assumed concentrated on the quarter-chord line, determination of the spanwise center of pressure fixes the center of pressure for the wing panel. It is only necessary then to project this point onto the reference chord to determine the aerodynamic-center location relative to this chord. The approximation arises from the fact that Weissinger considers the loading concentrated along the quarter-chord line, which is, of course, not strictly correct. However, it is apparent that as the wing is increasingly swept, the longitudinal location of the aerodynamic center relative to some geometric reference chord becomes increasingly a function of the spanwise location of the center of pressure and, hence, relatively less a function of chordwise loading. For example, on the wing that has little sweep (Fig. 7), changes in spanwise location of the center of pressure have little effect on the fore-and-aft location of the center of pressure and, hence, little effect on aerodynamic-center location. In contrast, on the highly swept wing, changes in spanwise location of the center of pressure produce a relatively large fore-and-aft movement on the wing center of pressure and aerodynamic center. Because the Weissinger method gives an accurate prediction of spanwise center of pressure, it follows that it should give a good prediction of the aerodynamic-center position on wings having appreciable sweep.

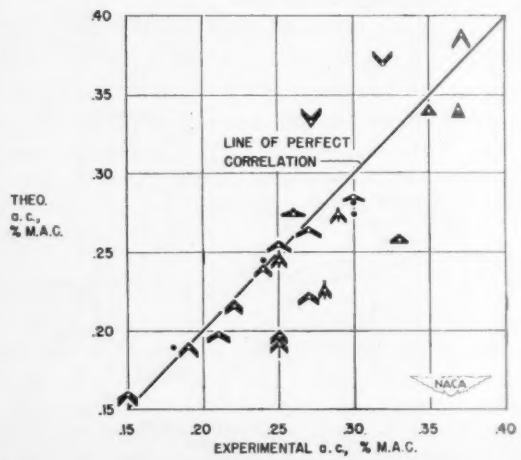

FIG. 8. Evaluation of Weissinger method for predicting aerodynamic center location.

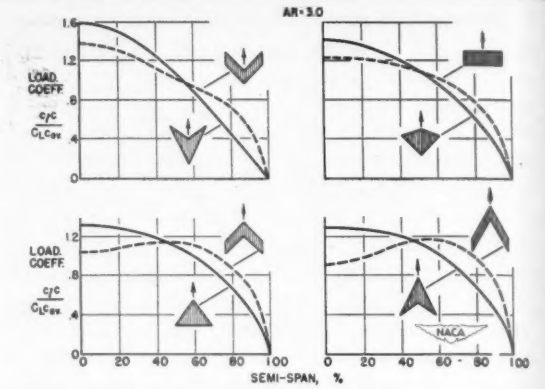

FIG. 9. Effect of sweep and taper ratio on span loading over wings of aspect ratio 3.0.

On swept wings the error of assuming that the loading is concentrated on the quarter-chord line is probably greatest at the root. On swept-forward wings it is known that the center of load at the root is ahead of the quarter-chord point, and on sweptback wings the center of load is behind the quarter-chord point as shown on Fig. 7. It might be expected then that use of the aforementioned procedure would result in predicted aerodynamic-center locations that were too far aft on swept-forward wings and too far forward on sweptback wings. Although far from being conclusive, such a trend is indicated in Fig. 8, which is a correlation of measured and predicted values of aerodynamic-center location. That is, the swept-forward wings are above the line of correlation; whereas in general the sweptback wings are either on or below the line.

With regard to the overall aerodynamic-center correlation, experiment and theory do not show so good a correlation as in the case of lift-curve slope. Beyond the probable effect of sweep on the loading at the wing root just mentioned, there is no systematic variation in the correlation with plan form, and most of the discrepancies in correlation are of the order of the accuracy with which the aerodynamic center usually can be determined by experiment. In any event, for 75 per cent of the plan forms the discrepancy is less than 2 per cent of the M.A.C. This is small compared to the effect of plan form which results in movements of the aerodynamic center of as much as 25 per cent of the M.A.C.

All of the foregoing correlations have been made at zero lift, since, as previously pointed out, the theoretical method strictly applies only at zero lift. However, since the aerodynamic characteristics are to a first order linear up to angles of attack where separation occurs, the theoretically predicted characteristics can be used with good accuracy up to this point. In summary, it is our belief that the Weissinger method gives span loading, lift-curve slope, and aerodynamic center with sufficient accuracy for use in preliminary design studies.

Effects of Plan Form on Aerodynamic Characteristics

Because there are so little span-loading data available for unusual plan forms, the effect of plan form on

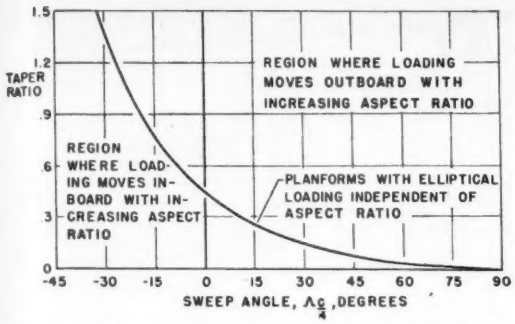
TAPER RATIO
REGION WHERE LOADING MOVES OUTBOARD WITH INCREASING ASPECT RATIO
REGION WHERE LOADING MOVES INBOARD WITH INCREASING ASPECT RATIO
PLANFORMS WITH ELLIPTICAL LOADING INDEPENDENT OF ASPECT RATIO
SWEEP ANGLE, $\Lambda_{\frac{c}{4}}$, DEGREES

FIG. 10. Taper ratio—sweep angle relationship giving elliptic loading.

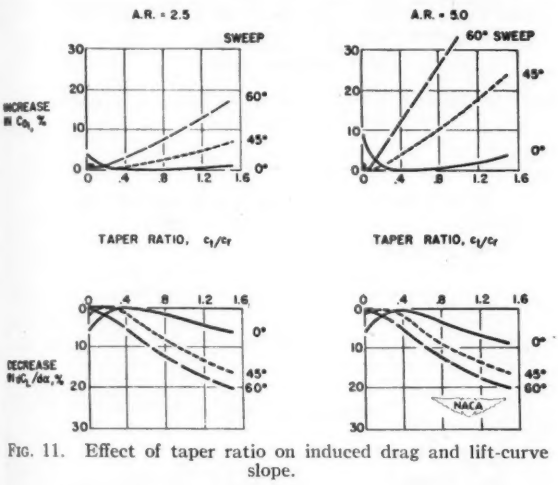

FIG. 11. Effect of taper ratio on induced drag and lift-curve slope.

loading as shown by the Weissinger method is particularly interesting. The effect of sweep and taper ratio on the loading of wings of aspect ratio 3 is shown in Fig. 9. The movement of loading toward the root as the wing is swept forward and toward the tip as the wing is swept back is evident. Also, for each angle of sweep, tapering a wing to a point shifts the loading inboard. However, at high angles of sweep—as for example, the 60° sweptback wing—the change in loading due to taper is nearly twice the change on the unswept wing, which suggests that taper exerts a much stronger influence on the characteristics of swept wings than on unswept wings. This will be borne out by the results to be shown later.

Further examination of the loading over swept wings has revealed that for each angle of sweep there is a taper ratio for which aspect ratio has little effect on the span loading and for which the span loading is practically elliptical. This relationship is shown in Fig. 10. As the wing is swept forward, more inverse taper is required to maintain elliptic loading, and, as the wing is swept back, more taper is required. For plan forms above the line, loading moves outboard with increasing aspect ratio; conversely, for plan forms below the line, loading moves inboard with increasing aspect ratio. Because of the elliptic loading, minimum induced drag and maximum lift-curve slope are obtained for wings on this line. In other words, for a given angle of sweep, deviation in taper ratio from the value given by this curve increases the induced drag and decreases the lift-curve slope. This is illustrated in Fig. 11. On an unswept wing of aspect ratio 2.5, the induced drag and lift-curve slope change relatively little as taper is varied from that giving elliptic loading But as the wing is swept, the effect of taper is more pronounced, so that, on a 60° swept wing, untapering the wing from a taper ratio of 0.1 to 1.0 increases the induced drag by 10 per cent and decreases the lift-curve slope by 15 per cent. The effects of taper ratio on induced drag are tripled on the aspect ratio 5 wing. Increases of this magnitude in the induced drag will seriously reduce the lift-drag ratio, which in turn will reduce the flight range and impair the landing and take-off performance.

The effects of plan forms on lift-curve slope are shown in Fig. 12. The lift-curve slope is given as a function of sweep for taper ratios of 0 and 1.5 and for aspect ratios of 1.5, 8, and infinity. The curve for infinite aspect ratio is obtained from simple sweep theory and, hence, is a cosine curve. Note that for both taper ratios the effect of aspect ratio falls off with increase in sweep; for example, the increment in lift-curve slope produced by a change in aspect ratio from 1.5 to 8.0 is roughly halved as sweep is increased from 0° to 50°. For low aspect ratios, small angles of sweep have little effect on lift-curve slope. Also note that on sweptback wings, tapering a wing to a more pointed plan form increases the lift-curve slope; whereas on swept-forward wings, inverse taper produces a similar increase in lift-curve slope. On highly swept wings this effect is of such magnitude that taper ratio exerts as great an influence on lift-curve slope as does aspect ratio. This is particularly noteworthy since heretofore aspect ratio has been considered to be the most important parameter.

Sample charts of aerodynamic-center location are plotted as a function of sweep for taper ratios of 0, 0.5, and 1.5 and for aspect ratios of 1.5, 3.5, and 8.0 as shown on Fig. 13. For the plan forms investigated, the aerodynamic-center location ranged from as far forward as 15 per cent of the M.A.C. to as far back as 40 per cent of the M.A.C. In contrast, the aerodynamic

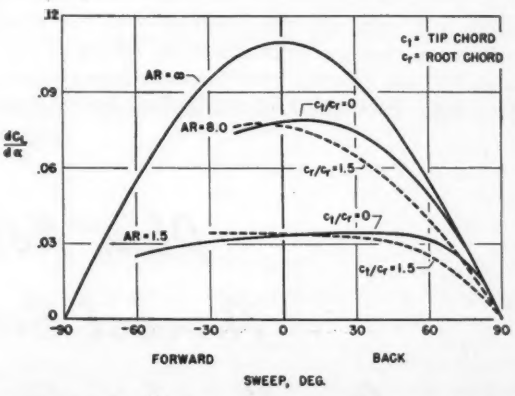

FIG. 12. Effect of sweep, aspect ratio and taper ratio on lift-curve slope.

center on unswept wings is seldom more than 2 or 3 per cent of the M.A.C. from the 25 per cent M.A.C. point. On highly tapered wings, sweepback moves the aerodynamic center aft and sweep forward moves it forward. As taper is decreased, the trend is reversed, so that on wings having inverse taper sweepback moves the aerodynamic center forward while sweep forward moves the aerodynamic center back. The magnitude of this movement in each case is generally increased by increase in aspect ratio.

Effects of Mach Number

All of the results obtained through use of the Weissinger method apply only to incompressible flow. However, through an application of the Prandtl-Glauert rule it is possible to account for the effects of compressibility on span-loading characteristics for speeds below the critical speed. The method, which has been summarized in some detail by Dickson of the R.A.E., translates the effect of compressibility into an effective change in plan form, in addition to the well-known increase in section pressures.

The lift distribution of an airfoil at a given Mach Number is obtained by determining the lift distribution in incompressible flow of an equivalent airfoil having lateral dimensions reduced by $\sqrt{1-M^2}$. Thus, as shown in Fig. 14, the load distribution at a Mach Number of 0.7 for a wing of aspect ratio 5.0 and 30° sweepback can be obtained by computing the incompressible loading on an equivalent wing of aspect ratio of 3.5 and 40° sweepback (in Fig. 14, λ is the taper ratio and Λ is the angle of sweep of the quarter-chord line). Spanwise center of pressure and aerodynamic center can be obtained in a similar manner. However, lift-curve slope and induced drag, obtained for the equivalent wing, must be multiplied by $1/\sqrt{1-M^2}$ and $\sqrt{1-M^2}$, respectively, to obtain the correct values for the original wing at a Mach Number of 0.7.

It is apparent that if such an approach serves to predict accurately the effects of compressibility, it can be used in conjunction with the Weissinger method to give a rapid estimation of the effects of Mach Number on wings flying at speeds below the critical speed.

It has been clearly demonstrated that the Weissinger method will yield accurate predictions of important aerodynamic characteristics where the effects of compressibility are absent; however, insufficient experimental data exist to establish firmly the accuracy of the foregoing method for predicting the effects of Mach Number; until this is done, the results of applying this procedure must remain somewhat in question.

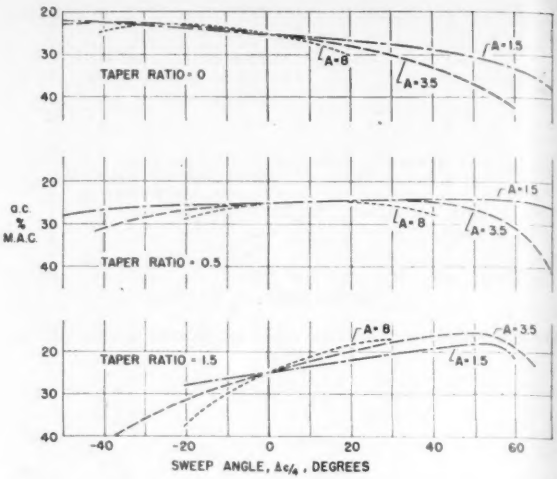

Fig. 13. Effect of sweep, aspect ratio and taper ratio on aerodynamic center location.

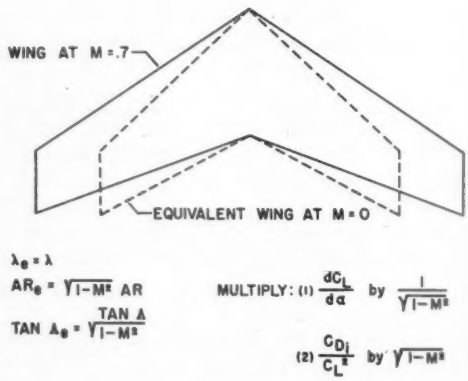

Fig. 14. Determination of Mach Number effects through use of an equivalent wing.

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[1] Van Dorn, Nicholas H., and DeYoung, John, *A Comparison of Three Theoretical Methods of Calculating Span Load Distribution on Swept Wings*, N.A.C.A. T.N. No. 1476, November, 1947.

[2] DeYoung, John, *Theoretical Additional Span Loading Characteristics of Wings With Arbitrary Sweep, Aspect Ratio, and Taper Ratio*, N.A.C A. T.N. No. 1491, December, 1947.

Plan Now to Attend
Annual Summer Meeting
Los Angeles, California, July 14–16

I.A.S. Briefs

Summaries of current papers received for publication or presentation at I. A. S. meetings

Interference Between Wing and Body at Supersonic Speeds—Theory and Numerical Application

By

Carlo Ferrari

Cornell Aeronautical Laboratory

The supersonic flow past a body of revolution with pointed nose and carrying a wing is treated. The flow at infinity is uniform, at a small angle of attack with respect to both the axis of the body and the chord of the wing, and parallel to the plane of symmetry of the body-wing combination. The wing profile is assumed to be that of a flat plate. All perturbations on the uniform stream are assumed to be so small that it is legitimate to linearize the equation of motion.

The following are determined:

(1) Interference of the wing on the streamlined body, assuming that the induced field generated by the wing is that which would exist around the wing if it were placed in the uniform stream alone.

(2) Interference of the body on the wing, neglecting the distortion of the field around the body due to the presence of the wing.

A detailed numerical example serves to show that the interference effect of the wing upon the body is about half as great as the effect of the body upon the wing, when the lift increments are compared, but the moment increment on the body is nearly two and a half times as large as the increment experienced by the wing. An optimum angle of wing setting for least drag is also determined.

Buckling of a Column with Elastic Supports

By

T. H. Lin and K. S. Ching

Chinese Air Force

In this paper, the buckling of a column with equally spaced elastic supports under compressive load is investigated, and an equation is derived for any number of equally spaced elastic supports. It is assumed that the elastic supports give only linear but not rotational restraints on the bar, and the bar itself is in long column failure. As the spring constant of the elastic supports increases, waves of buckling increase until there is one half wave between every two adjacent supports and until further increase in the spring constant does not increase the buckling load. This constant is called the maximum critical elastic constant. An equation for calculating this constant is given. Curves of the ratio of buckling load to Euler load vs. spring constant for different modes of buckling are shown so that, with a given column on equally spaced elastic supports of known spring constant, the buckling load can be readily calculated.

These papers will appear in full in June and later issues of the JOURNAL.

Preprints of these papers are not available at this time.

Harmonic and Transient Motion of a Swept Wing in Supersonic Flow

By

John W. Miles

University of California

The results of previous papers on the harmonic and transient motion and loading of two-dimensional airfoils in supersonic flow are extended to include the infinite swept airfoil, provided that the component of flow normal to the leading edge remains supersonic. It is shown that the various normal force derivatives are reduced by the cosine of the sweepback angle and that the effective Mach Number corresponds to the component of flow normal to the leading edge. This result is related to the invariance of the magnitude of the circulation under sweepback and Busemann's rule with respect to compressibility effects. The flutter of a swept wing is considered, and it is pointed out that sweepback introduces additional aerodynamic coupling between torsion and bending. The flutter of a supersonic swept wing with subsonic leading edge is discussed, and an approximate treatment is suggested.

Stability of an Oscillating Airfoil in a Supersonic Airflow

By

M. V. Barton

The University of Texas

The conditions for the determination of the stability of a two-dimensional airfoil oscillating harmonically with two degrees of freedom in a supersonic flow are developed. The stability is expressed in terms of the position of the axis of rotation of the airfoil, the reduced frequency, the Mach Number, and the ratio of the amplitudes of the torsional and flexure

modes. The phase angle between the modes and evaluations are made for Mach Numbers ranging from 1.2 to 2.0 and for reduced frequencies from 0.1 to 2.0. The range of reduced frequencies and Mach Numbers for instability of a two-degree-of-freedom system are indicated. It is shown that instability for single-degree-of-freedom torsional motion does not occur at a Mach Number greater than 1.58. The effects of the pivot position on the stability for various phase angles and amplitude ratios of the two modes of motion of the airfoil are discussed.

Tables of aerodynamic parameters for an oscillating airfoil in a supersonic flow are given as a supplement to previously published values.

Helicopter Control and Stability in Hovering Flight

By

R. H. Miller

Massachusetts Institute of Technology

The stability and control characteristics of several different types of helicopters have been evaluated and compared with the characteristics of a conventional airplane. It is concluded that some form of automatic stabilization is indicated if more desirable handling qualities are to be attained, but, if stability is not to be achieved at the expense of controllability, means of increasing the control effectiveness are evidently necessary. Methods of accomplishing this are discussed, and it is shown that, in some cases, response and stability characteristics approaching those of an airplane may be achieved. The equations of motion for the helicopter and rotor blades have been developed in nondimensional form in such a way as to include the effects of flapping and feathering hinge offsets and restraint about these hinges. Both single- and twin-rotor helicopters have been considered and the complete solution simplified wherever possible, without sacrificing engineering accuracy. The effects of automatic stabilization have been included in the solution in a manner that, it is believed, will cover most applications and an elementary servo system analyzed by means of the frequency response method.

Problem Types in the Theory of Perfectly Plastic Materials

By

W. Prager

Brown University

Typical problems of the theory of perfectly plastic materials are discussed for the example given. A simple graphical representation is developed which facilitates the study of the states of stress and residual stress produced by slowly varying the load.

For monotonically increasing load, three domains of mechanical behavior are defined: elastic deformation, contained plastic deformation, and unrestricted plastic flow. In the domain of contained plastic deformation the instantaneous stresses in the structure depend only on the instantaneous load and can be found from the minimum principle of Haar and von Kármán.

However, if unloading is permitted, the stresses depend on the complete history of loading, and the principle of Haar and von Kármán must be replaced by a minimum principle recently developed by H. J. Greenberg.

Cases in which the precise loading program is known beforehand are not often encountered in engineering. As a rule, the only extremes known are those between which the load will vary. Under certain conditions, the structure will then "shake down" to a state of residual stress such that all further variations of the load between the given extremes are supported in a purely elastic manner. This "state of residual stress" is independent of the precise program of loading. Conditions for the existence of such a state of residual stress are discussed, and a minimum principle is conjectured from which this state may be determined.

Finally, structural stability in the plastic range is discussed. It is pointed out that the customary formulation of the stability problem for conservative systems (elastic range) is not adequate for nonconservative systems (plastic range).

The Rolling Moment Due to Sideslip for a Swept Wing

By

John W. Miles

University of California

Using strip theory, the rolling moment coefficient due to sideslip ($c_{l\beta}$) is computed for a swept wing, a result that has been erroneously derived in the literature. Multhopp's theory for a wing in sideslip and a modification of Prandtl's elliptic wing theory are used to correct the result for induction effects. The effects of geometrical dihedral, twist, camber, elevons, or flaps, and fuselage are also treated. The results are compared with available experimental data, and it is found that, if Weissinger's value of $c_{l\beta}$ for a straight wing is added to the result for a swept wing, the agreement is satisfactory for most purposes. It is remarked that these results are subject to modification by aeroelastic deflection of the wing.

Torsion-Bending Stresses in Box Beams

By

Robert A. Williamson

Lockheed Aircraft Corporation

Since the problem of determining bending stresses due to torsion in a box beam is closely related to the problem of finding end moments in a continuous beam, it is possible to determine torsion-bending stresses by a procedure similar to the Cross method of moment distribution widely used in the analysis of continuous frames.

The method, as applied to the simplest case, the prismatic box of rectangular section, is described in this paper. Cases involving flexible bulkheads and complete cutouts of one or both surfaces are considered. Expressions for constants analogous to the fixed end moments, stiffness, carry-over, and rigidity factors of moment distribution are presented, and application of the method is illustrated with numerical examples.

An Improved Schlieren Apparatus

By

Frank W. Barry and Gilbert M. Edelman

Massachusetts Institute of Technology

This paper describes an improved schlieren apparatus that forms two separate images of the test section simultaneously. One image indicates vertical density gradients; the other, horizontal density gradients. The determination of transient

density fields is more accurate with this modified schlieren system than with the ordinary schlieren system taking two successive pictures. At present, this apparatus is being used to study the interaction between shock waves and boundary layers.

A Note on Transverse Bending of Beams Having Both Translating and Rotating Mass Elements

By

R. H. Scanlan

Rensselaer Polytechnic Institute

The usual equations of transverse vibration of beams take into consideration only the translation of the distributed mass of the beam and not its rotation. In particular, this is true for the equations applied to beams of variable mass and section (as, for example, aircraft wings), the structural characteristics of which are approximated by a matrix of deflection influence coefficients at a finite set of points. This note presents a simple extension of these ideas to include effects of inertia elements in the beam which rotate, as well as translate, during beam transverse vibration.

Variational Method in the Theory of Compressible Fluid

By

Chi-Teh Wang

New York University

The variational principle in hydrodynamics was first studied by Hargreaves, who has shown that, when the hydrodynamic equations are satisfied, the integrand in the variational principle is a linear function of the pressure. For steady, irrotational flows, Bateman has shown that the integrand is the pressure only, which can be written as a function of the velocity potential ϕ. A direct method to obtain approximate solution in the case of subsonic flow of a compressible fluid can therefore be formulated following the Rayleigh-Ritz method instead of solving the original nonlinear differential equations. In applying this method to the case of a compressible fluid passing an arbitrary airfoil, however, there is the difficulty that it is not easy to assume the potential function satisfying the boundary conditions. Braun, in his dissertation at Göttingen under Prandtl, attempted to solve the linearized problem by the variation method and succeeded only in the case of compressible flow passing a circular cylinder, and even so the calculations were erroneous. The nonlinear problem of compressible flow passing an arbitrary airfoil has been formulated in this paper. It is proved that by conformal transformation the velocity potential can be set up to satisfy the boundary conditions in the general case, and, hence, the Rayleigh-Ritz method can be applied. It is also shown that, by using the Theory of Residues in the integration and modified Crout method in solving the resulting simultaneous equations, the computational labor can be materially reduced. Since the variational principle is valid for subsonic, sonic, and supersonic flows, the possibility of applying it to the study of mixed flow is indicated. A numerical example of the nonlinear problem of the compressible flow around a circular cylinder is carried out, and the results compare favorably with those found by the existing methods.

Finite Deflections of Sandwich Plates

By

Eric Reissner

Massachusetts Institute of Technology

This paper gives the basic differential equations for finite transverse deflections of sandwich plates under the following assumptions. The plate consists of a core layer and of two face layers of such construction that the face-parallel stresses in the core and the variation of the face stresses over the thickness of the face layers are negligible. The resultant equations permit the analysis of the effect of transverse shear stress deformation and transverse normal stress deformation in the core on the overall behavior of the plate. It is shown that, in general, the effect of the transverse normal stresses in the core is negligibly small compared with the effect of the transverse shear stresses. The equations, when simplified by the omission of the transverse normal stress terms, are brought into a form that is suitable for the solution of rectangular-plate problems.

It is further shown that the range of deflections for which the linear ("small deflection") theory is adequate decreases in accordance with a simple explicit formula as the core is made softer relative to the faces.

The finite deflection equations are used to obtain plate buckling equations, which include the effect of transverse shear stress deformation on buckling loads. A typical buckling problem is solved and discussed.

Feature Articles Coming in the July Review

"Automatic Aircraft Control," by James L. Anast, All-Weather Flying Division, Air Materiel Command

"External Sound Levels of Aircraft," by R. L. Field, T. M. Edwards, P. Kangas, and G. L. Pigman, Civil Aeronautics Administration

"Loss Prevention Programs in Aviation," by Jerome Lederer, Aero Insurance Underwriters

"The Application of Gas Turbines to Aircraft," Arthur N. Tifford, Aviation Gas Turbine Division, Westinghouse Electric Corporation

I.A.S. Preprints

Preprints of Flight Propulsion Meeting Papers Currently Available

No.

137 Experimental Study of Cooling by Injection of a Fluid Through a Porous Material—Pol Duwez and H. L. Wheeler, Jr., Jet Propulsion Laboratory, California Institute of Technology

138 The Flow of a Perfect Fluid Through an Axial Turbomachine with Prescribed Blade Loading—Frank E. Marble, National Research Council Predoctoral Fellow, Guggenheim Aeronautical Laboratory, California Institute of Technology

139 Service Experience with Turbojets—J. W. Bailey, Head, Engineering Services, Allison Division, General Motors Corporation

140 An Evaluation of Engine Design Compromises—Neil Burgess, Aircraft Gas Turbine Division, General Electric Company

141 Layout and Preliminary Design Problems—Milton U. Clauser, Chief, Mechanics Section, Douglas Aircraft Company, Inc.

No:

142 Air Inlets and Nacelles—William J. Blatz, Project Aerodynamicist, McDonnell Aircraft Corporation

143 Tailpipe, Nozzle, and Jets—Herbert C. Towle, Jr., Principal Thermodynamicist, Republic Aviation Corporation

144 Accessory Equipment in Turbojet Installations—F. H. Sharp, Assistant Project Engineer, Consolidated Vultee Aircraft Corporation

145 The Four-Stroke Spark Ignition Compound Engine—LeRoy V. Humble and Cecile G. Martin, N.A.C.A.

146 The Two-Stroke Compression Ignition Compound Engine—Arnold E. Biermann and Max J. Tauschek, N.A.C.A.

147 The Gas Turbine Propeller Engine—Robert O. Bullock and Robert English, N.A.C.A.

148 The Turbojet Engine—Reece V. Hensley and Newell D. Sanders, N.A.C.A.

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No.

107 The Testing of Rotors for Fatigue Life—Jonathan Winson, Consultant, Prewitt Aircraft Company

109 Chordwise and Beamwise Natural Frequencies of Rotor Blades—Gabriel Horvay, Engineering General Division, General Electric Company

110 The Helicopter Control Rotor—Joseph Stuart, III, Project Engineer, United Helicopters, Incorporated

117 N.A.C.A. Investigation of Gas-Turbine Blade Cooling—H. Ellerbrock, Flight Propulsion Research Laboratory, N.A.C.A.

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134 The Transient Reaction of a Two-Dimensional Wing at Supersonic Speed Due to Change in Angle of Attack—Chieh-Chien Chang, Associate Professor, Department of Aeronautics, The Johns Hopkins University

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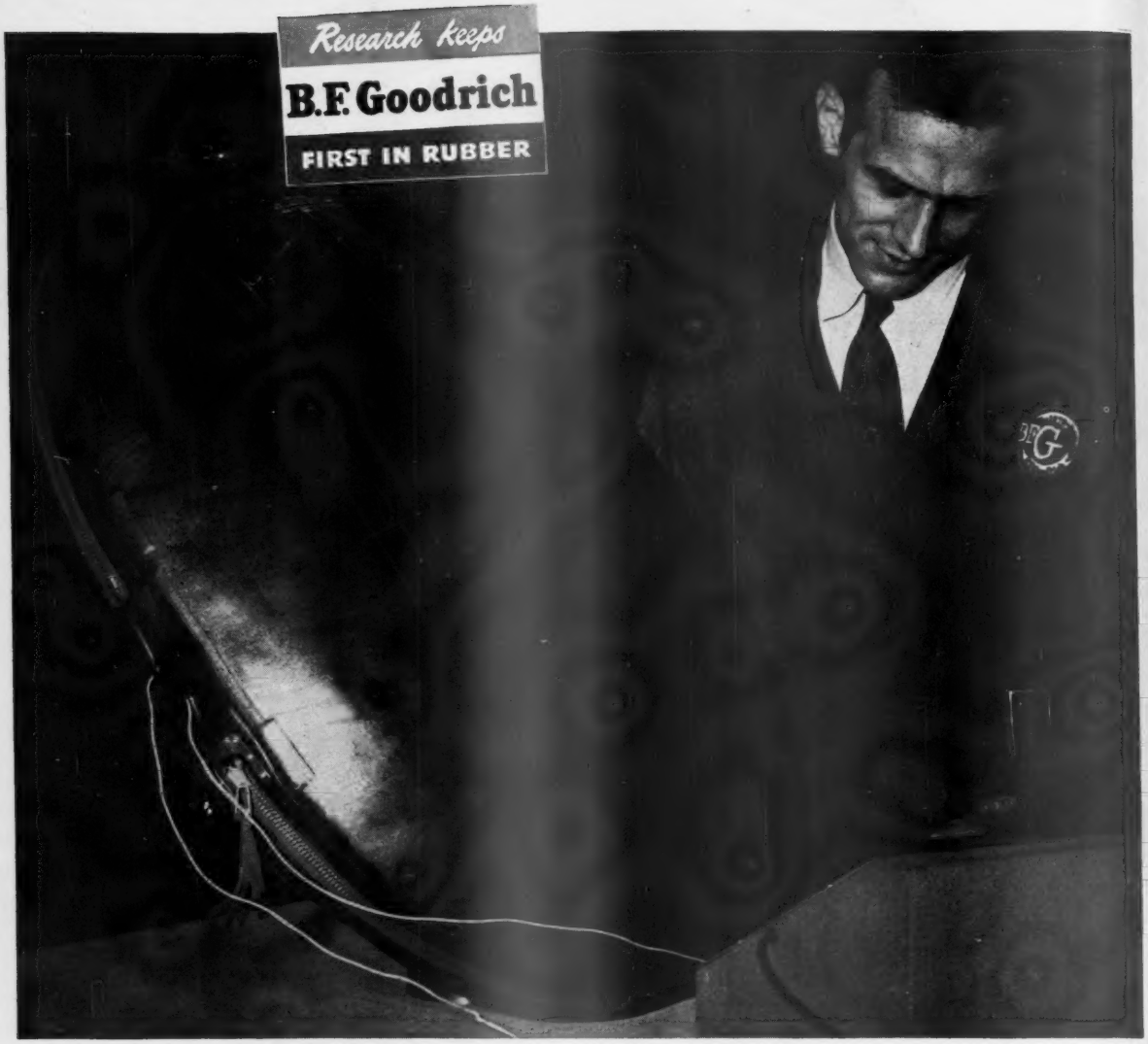

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Reviewed by Dr. N. J. Hoff, Polytechnic Institute of Brooklyn

Cours d'Aéronautique. Émile Allard 79
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Aircraft Engines of the World, 1948. Paul H. Wilkinson 80
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Aerodynamics (2)

AERODYNAMIC LOADS

Tables Numériques pour le Calcul de la Répartition des Charges Aérodynamiques Suivant l'Envergure d'une Aile (Numerical Tables for the Calculation of the Aerodynamic Load Distribution Along the Wing Span). Joseph Pérès, with the collaboration of Lucien Romani. *Groupement pour le Développement des Recherches Aéronautiques (G.R.A.), Rapport Technique No. 9,* 1943. 134 pp., figs., tables. (In French.)

BOUNDARY LAYER

Maintaining Laminar Flow in the Boundary Layer Using a Swept-Back Wing. Brennecke. (*ZWB/UM/3151,* September 13, 1944.) *U.S., N.A.C.A., Technical Memorandum No. 1180,* February, 1948. 9 pp., illus. 2 references.

The positions of boundary-layer transition were ascertained experimentally by the dust precipitation method for a sweptback and a straight wing of like surface conditions, profile, aspect ratio, and taper and were compared for the same angle of attack at a Reynolds Number of 5.6×10^5. The sweptback wing in a definite range of angle of attack resulted in a backward shift of the transition point on the suction side of the wing. This confirms the favorable effect of sweepback on the position of the transition point predicted by Lippisch.

CONTROL SURFACES

Elevator Control on Firefly F. Mk. I and N.F. Mk. II Aircraft. D. R. H. Dickinson. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2202,* March, 1947. 12 pp., figs. 1 reference. British Information Service, New York. $0.90.

A résumé of previously published interim reports. Increasing the tailplane incidence and retaining the fabric-covered elevator reduced the stick forces required in out-of-trim dives and the acceleration on releasing the stick in such dives. The trimmer movement required after a change in speed was reduced, but the stick forces for maneuvering from a trimmed condition of flight were increased. A metal-covered elevator gave a further reduction in the three features already reduced but made no appreciable change in the stick force for maneuvering. However, there was considerable improvement in the longitudinal stability characteristics. Improvement in the stick forces for maneuvering was finally obtained, taking advantage of the increased longitudinal stability, by shifting the center of gravity aft. The same effect, it was found, could also be obtained by the use of a spring-tab control.

Wind-Tunnel Investigations of an N.A.C.A. 23012 Airfoil With a 30-Per Cent-Chord Maxwell Slat and With Trailing-Edge Flaps. John G. Lowry and John W. McKee. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-693),* June, 1941. 24 pp., diagrs., tables. 6 references.

Tests of Bell XP-63 Low-Drag Wing Model With Split Flap. W. J. Underwood. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-769),* September, 1941. 3 pp., table. 1 reference.

Tests of 0.14-Scale Models of the Control Surfaces of Army Project MX-511 in Attitudes Simulating Spins. H. Page Hoggard and John R. Hagerman. *U.S., N.A.C.A., Memorandum Report No. L5D12a (Wartime Report No. L-572),* April, 1945. 44 pp., illus. 1 reference.

Flight Studies of the Horizontal-Tail Loads Experienced by a Fighter Airplane in Abrupt Maneuvers. Flight Research Maneuvers Section. *U.S., N.A.C.A., Report No. 792,* 1944. 16 pp., illus., tables. U.S. Govt. Printing Office, Washington. $0.15.

Wind-Tunnel Investigation of an N.A.C.A. 0009 Airfoil With 0.25- and 0.50-Airfoil-Chord Plain Flaps Tested Independently and in Combination. M. Leroy Spearman. *U.S., N.A.C.A., Technical Note No. 1517,* March, 1948. 34 pp., diagrs. 5 references.

Measurements of the Pressure Distribution on the Horizontal-Tail Surface of a Typical Propeller-Driven Pursuit Airplane in Flight. III—Tail Loads in Abrupt Pull-Up Push-Down Maneuvers. Melvin Sadoff and Lawrence A. Clousing. *U.S., N.A.C.A., Technical Note No. 1539,* February, 1948. 61 pp., illus. 13 references.

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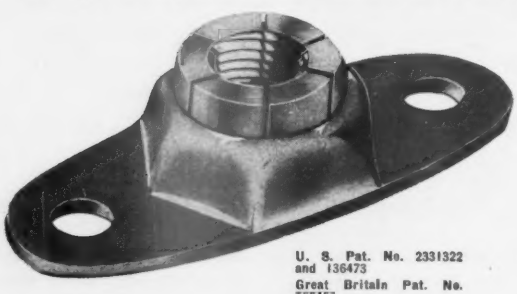

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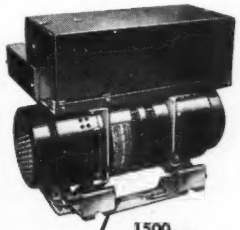
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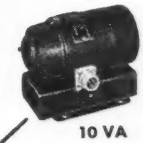
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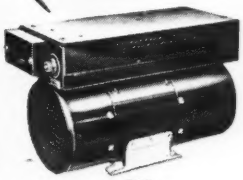
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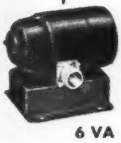
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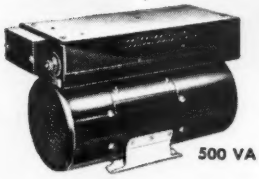
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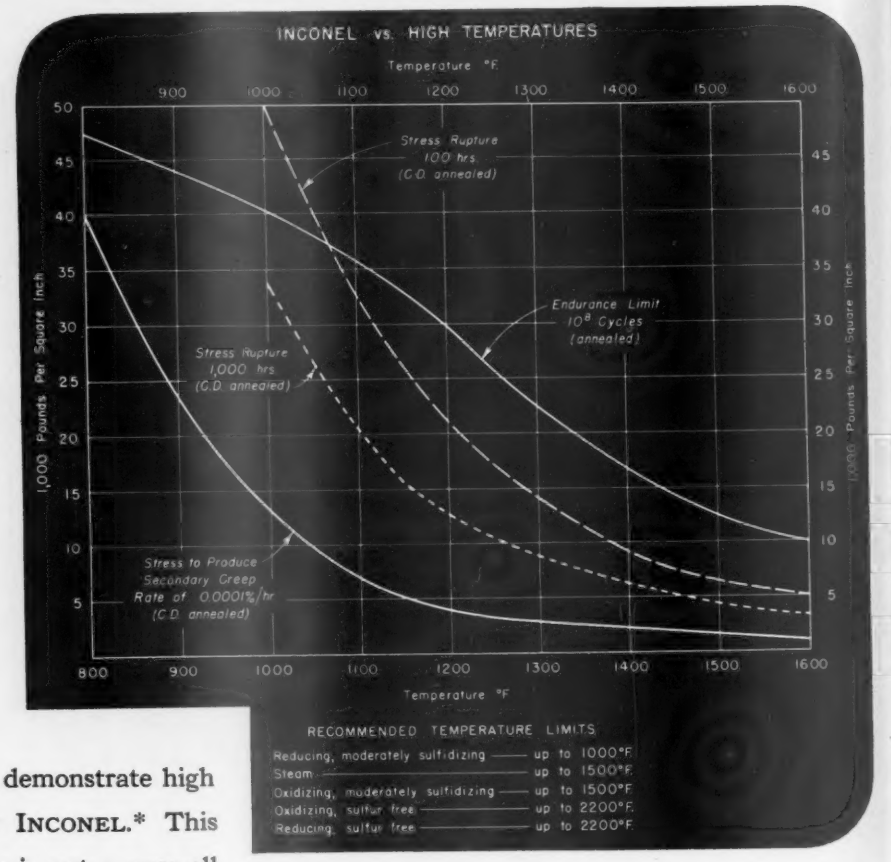

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Tests of Two Models Representing Intermediate Inboard and Outboard Wing Sections of the XB-36 Airplane. Seymour M. Bogdonoff. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-662)*, January, 1943. 33 pp., diagrs.

FLUID MECHANICS & AERODYNAMIC THEORY

The Computation of Mach Number. G. Pickup and R. E. J. White. *Aircraft Engineering*, Vol. 20, No. 227, January, 1948, Supplement. 2 pp., figs.

Two charts. One shows the variation of the Mach Number with true air speeds from 700 to 2,300 ft. per sec. at altitudes from 0 to 36,000 ft., and also the Mach Number variation with pitot-static head ratios from 5.0 to 1.2 at 800° and at 500°C. or less absolute total temperature. The other chart gives curves of specific heat at constant pressure, against absolute total temperature, for products of combustion, with air-fuel ratio by weight as parameter. It also shows curves of Mach Number against pitot-static head ratio, with specific heat at constant pressure as parameter.

Introduction to Shock Wave Theory. J. G. Coffin. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Paper No. 101*, 1947. 106 pp., diagrs. $3.50. (Cf. AER 7/47:28.)

INTERNAL FLOW

High-Speed Flow Through Cambered Rotating Grids. Frank L. Wattendorf. *Journal of the Aeronautical Sciences*, Vol. 15, No. 4, April, 1948, pp. 243–247, diagrs. 4 references.

A discussion of the large increase in the ideal stage pressure ratios which can theoretically be obtained with axial compressors using highly cambered blades of the curved lattice type. The flow diagrams under ideal adiabatic conditions are given for four cases: subsonic flow throughout; subsonic axial velocity, subsonic flow in the rotor, supersonic flow in the downstream stator; subsonic axial velocity, supersonic flow in the rotor and stator; and supersonic flow throughout. In the third case a possible compression ratio has been calculated.

Flow and Pressure Conditions Behind Gas Turbine Guide Vane Ring With Straight and Curved Blades. F. Korbacher. (*Luftfahrtforschungsanstalt Hermann Göring, Braunschweig, ZWB/FB/ 1816*, May, 1943). *U.S., Air Force, Translation No. F-TS-2741-RE*, February, 1948. 65 pp., illus. 13 references.

Report of tests conducted to verify the calculations of E. Eckert for the flow and pressure conditions in the swirl flow behind curved and straight-bladed vane rings of axial-flow turbines. Measurements were made of the torque, the quantity of flow per sec., the static and total pressures behind the vane ring, and the outlet-flow angles radially along the blade. From these last measurements both the velocity and direction of flow can be determined at any point immediately behind the vane ring. The measurements of torque and quantity of flow served to test the accuracy of the readings taken with the Prandtl pitot and the cylindrical tubes. Major deviations in the measurements made at varying distances from the vane ring were traced to the effect of the dead water region that forms around the inner cylinder. This region shows a pronounced reverse flow at the inner cylinder and extends outward from a radial position between 35 and 44 mm. for a depth of 55 to 60 mm. Although the coincidence between the calculated and the measured values was excellent, a deviation of 20 per cent was observed in the torque with the curved blade ring. This was found to have been caused by an exaggeration of the angles in blades with profiles as used in conformance with current practice.

Efficiency Tests of a Single-Stage Impulse Turbine Having an 11.0-Inch Pitch-Line Diameter Wheel with Air as the Driving Fluid. David S. Gabriel and L. Robert Carman. *U.S., N.A.C.A., Advance Confidential Report No. E5C30 (Wartime Report No. E-216)*, April, 1945. 17 pp., illus.

The Performance of a Single-Stage Impulse Turbine Having an 11.0-Inch Pitch-Line Diameter Wheel With Cast Airfoil-Shaped and Bent Sheet-Metal Nozzle Blades. David S. Gabriel and L. Robert Carman. *U.S., N.A.C.A., Advance Restricted Report No. E5H31 (Wartime Report No. E-233)*, September, 1945. 10 pp., diagrs. 1 reference.

PERFORMANCE

Some Bomber Range Considerations. J. Jones. *Aircraft Engineering*, Vol. 20, No. 227, January, 1948, pp. 18, 19, figs. A modification of the Breguet Range Equation in which range is correlated with the fuel, oil, and bomb load.

STABILITY & CONTROL

The Moment Coefficient for Lateral Motion. Wenk. (*ZWB/UM/766*, March, 1943.) *Cornell Aeronautical Laboratory, Translation*, March, 1948. 22 pp., figs. 7 references.

Starting with the yawing moment coefficients expressed in the principal inertia axes system of the aircraft, combined moment coefficients are derived from the lateral stability theory of an aircraft with fixed rudder. These combined coefficients permit a fundamentally simpler formulation than do other systems. While they are based primarily on the experimental system of axes, they display a simple relationship to the moment coefficient of the principal inertia axes system. If the concept of a virtual moment of inertia is used, the combined moment coefficients can be given a mechanical significance by the use of the torque ellipsoid from gyroscope theory.

Flight Measurements of Static and Dynamic Longitudinal Stability Characteristics of Two Twin-Engined Monoplanes—the Beaufighter IF and the Boston III. D. E. Morris and H. G. Alston. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2191*, January, 1945. 53 pp., diagrs. 7 references. British Information Services, New York. $2.90.

Full-Scale Tunnel Tests of a Flying Model of the Curtiss XP-55 Airplane. William J. Biebel. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-627)*, January, 1943. 40 pp., illus.

Fighter Planes Gain High Speed At Sacrifice of Maneuverability. *Aviation Week*, Vol. 48, No. 9, March 1, 1948, p. 18. 5 references.

A brief résumé of recent trends in fighter aircraft design. High wing loading or relative density with respect to the atmosphere, high wing incidence, wing and fuselage mass distribution, and the use of swept wings reduce the lateral stability and decrease the maneuverability of high-speed aircraft.

Free-Spinning-Tunnel Tests of a 1/23.75-Scale Model of the Douglas DC-3 Airplane. Oscar Seidman and George F. MacDougall. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-783)*, June, 1942. 40 pp., illus. 8 references.

Spin-Tunnel Tests of a 1/57.33-Scale Model of the Northrop XB-35 Airplane. Robert W. Kamm and Philip W. Pepoon. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-739)*, April, 1944. 35 pp., illus. 2 references.

Investigations of Diving Moments of a Pursuit Airplane in the Ames 16-Foot High-Speed Wind Tunnel. Albert L. Erickson. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. A-65)*, October, 1942. 85 pp., illus., diagrs. 5 references.

High-Speed Wind-Tunnel Tests of a 1/6-Scale Model of a Twin-Engine Pursuit Airplane. Victor M. Ganzer. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. A-91)*, December, 1942. 100 pp., illus. 4 references.

WINGS & AIRFOILS

Low-Drag and Suction Airfoils. Sydney Goldstein. *Journal of the Aeronautical Sciences*, Vol. 15, No. 4, April, 1948, pp. 189–214, Discussion, pp. 215–220, figs. 40 references.

A survey of the theoretical and experimental progress that has been made to date in the development of airfoils especially designed to take maximum advantage of the control of boundary layer by suction removal. Heretofore low drag and high lift have been obtained by designing very thin wings with highly finished surfaces. On such wings the boundary layer was kept in a laminar condition over a major portion of the airfoil. The structural difficulties and the problems presented by the high finish led to the consideration of designing airfoil shapes that would give high lift with thick wings. The paper summarizes the mathematical airfoil theories, both approximate and exact, by which it was eventually possible to establish a configuration from a preselected velocity distribution over the surfaces of the airfoil. The problems presented by boundary separation were avoided by removal of the boundary layer by suction ahead of the point of transition to turbulence. The results of wind-tunnel tests made with one such wing proved to be in good agreement with the theoretical

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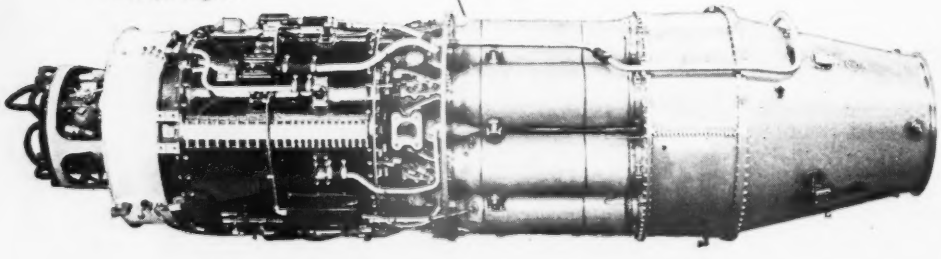

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calculations but showed the additional difficulties that must be met in the calculation of the quantities of air to be removed and in the design of the suction slot and its ducting. Further applications of this design principle to finite sweptback wings and to compressible flow with shocks are unknown fields. A still further application may be to the development of thin suction airfoils with high maximum lift coefficients. A possible solution of the problem of slot design may be the use of distributed suction through porous surfaces.

Bound and Trailing Vortices in the Linearised Theory of Supersonic Flow, and the Downwash in the Wake of a Delta Wing. A. Robinson and J. H. Hunter-Tod. *College of Aeronautics, Cranfield, England, Report No. 10,* October, 1947. 17 pp., diagrs. 3 references.

The field of flow around a flat airfoil at incidence can be regarded in linearized theory as the result of both bound and trailing vortices for supersonic as well as for low-speed flight. Given the lift distribution over an airfoil, this leads to a convenient method for calculating the flow around the airfoil at supersonic speeds. As an application of the results the downwash is calculated in the wake of a delta wing lying within the Mach cone emanating from its apex. The downwash is found to be least just aft the trailing edge and is everywhere less than the downflow at the airfoil. It increases steadily to a limiting value that is attained virtually within two chord lengths of the trailing edge. The ratio of the downwash to the downflow increases with Mach Number and apex angle.

Effect of Chordwise Location of Maximum Thickness on the Supersonic Wave Drag of Sweptback Wings. Kenneth Margolis. *U.S., N.A.C.A., Technical Note No. 1543,* March, 1948. 30 pp., diagrs. 4 references.

Using the linearized theory of supersonic flow, equations are derived for the wave drag of sweptback untapered wings at zero lift with thin double-wedge sections and arbitrary chordwise location of the maximum thickness. The optimum location of maximum thickness is found to be at 50 per cent chord at which minimum value a symmetrical variation in the wing wave-drag coefficient is exhibited. The drag variation is slight when there is considerable sweep behind the Mach lines, but the variation is marked at Mach Numbers at which the wing approaches or is swept ahead of the Mach lines. For tapered plan forms the sweep of the line of maximum thickness is an important parameter of the drag due to thickness.

The Pressure Distribution on Some Flat Laminar Aerofoils at Incidence at Supersonic Speeds. G. N. Ward. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2206,* March, 1946. 11 pp., diagrs. 6 references. British Information Services, New York. $0.90.

An investigation of cone field by use of the linearized equation for the velocity potential shows that certain finite polygonal wings may be treated by superposition of such fields. The results are obtained in the form of pressure distributions over certain semi-infinite wings and can be combined to give the pressure distribution for wings of finite span.

An Application of Falkner's Surface-Loading Method to Predictions of Hinge-Moment Parameters for Swept-Back Wings. Arthur L. Jones and Loma Sluder. *U.S., N.A.C.A., Technical Note No. 1506,* February, 1948. 17 pp., figs. 6 references.

Application of the Falkner lifting-surface-theory method to the prediction of hinge moment and, incidentally, lift parameters for sweptback plan forms has been made in an attempt to develop an analog to the existing lifting-surface-theory procedure for prediction of these parameters on unswept plan forms. For the two specific sweptback plan forms investigated, the hinge-moment predictions based on the Falkner method were not in good agreement with experimental values. The discrepancies are attributed to the effects of fluid viscosity which were not included.

Calculation of the Velocity Field of Swept-Back Wings at High Subsonic Speeds. B. Goethert. (*ZWB/DVL/M1.*) *U.S., Air Force, Translation No. F-TS-3183-RE,* February, 1948. 7 pp., diagrs.

A calculation of the increase of maximum local velocity with increasing Mach Number shows that for sweptback wings of infinite span this increase is slower than for wings without sweepback. With increasing angle of sweepback a substantial increase of the critical Mach Number was found to occur. Calculations agreed with measurements made at Göttingen.

The Lifting Vortex Surface as an Aid in Treating the Two-Dimensional Problem of Wing Theory. W. Birnbaum. (*Zeitschrift für Angewandte Mathematik und Mechanik,* Vol. 3, No. 4, 1923, pp. 290–297.) *Cornell Aeronautical Laboratory, Translation,* October, 1947. 10 pp., diagrs.

The Prandtl theory of the "lifting vortex" is applied to two-dimensional wing theory to obtain the chordwise lift distribution as a function of the airfoil shape. The simple lifting line is extended to the infinitely thin lifting surface, which carries the calculations to the next highest approximation. Since the third approximation would express surface vortexes on the boundary of an airfoil of finite thickness, if a given airfoil is replaced by a properly chosen mean line, there is a simple relationship between this contour and the lift distribution. For practical purposes the contour can be approximated by a curve of the third order. When the position of the center of pressure has been determined with sufficient precision, those conditions may be set up for which this position remains fixed as the angle of attack is varied. The advantage of this method over the rigorous treatment using conformal transformations is the linearity of all the equations which makes it possible to treat even complicated cases without extensive calculations. The theory of the bi-plane can also be approximated by a linear treatment using lifting vortex surfaces.

Note on the Influence of Spanwise Flow on Lift Distribution. W. P. Jones. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2181,* March, 1946. 3 pp., diagr. British Information Services, New York. $0.25.

By the use of Euler's equations for incompressible, inviscid flow, it is shown that the lift distribution for a thin flexible wing of any plan form is not appreciably affected provided the displacements of the wing are small.

The Aerodynamic Action on an Oscillating Profile at Supersonic Velocities. Camillo Possio. (*Pontificia Academia delle Scienze, Roma, Acta,* Vol. 1, No. 11, February, 1937, pp. 93–106.) *Cornell Aeronautical Laboratory, Translation,* January, 1948. 11 pp., figs.

An investigation of the application of linearized equations of continuity to the oscillations of a two-dimensional airfoil. The oscillations that occur around an axis parallel to the generatives of the airfoil are induced by uniform steady supersonic flow. The coefficients of lift and moment which are set forth are expressed in the form of series evolutions.

Note on Lifting Plane Theory With Special Reference to Falkner's Approximate Method and a Proposed Electrical Device for Measuring Downwash Distributions. W. P. Jones. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2225,* May, 1946. 4 pp., diagrs. 3 references. British Information Services, New York. $0.35.

For a rectangular wing of aspect ratio 6, Falkner's approximate downwash distributions corresponding to certain simple doublet distributions agree well with the results of exact lifting plane theory for points along the mid-chord axis of the wing up to about 0.8 span. An equivalent electrical network is suggested to replace Falkner's simplified vortex system.

Tests of a 45° Sweptback-Wing Model in the Langley Gust Tunnel. Harold B. Pierce. *U.S., N.A.C.A., Technical Note No. 1528,* February, 1948. 25 pp., illus. 6 references.

A comparison of the results of tests and calculations indicated that the gust load on sweptback-wing airplanes was dependent on the lift-curve slope of the equivalent straight wing multiplied by the cosine of the angle of sweep and on the effect of the gradual penetration of the gust on the unsteady-lift function. It was also indicated that the maximum acceleration increment in a gust for a sweptback-wing airplane would be much less than that for the same airplane with an equivalent straight wing.

The Production of Lift Independently of Incidence; A Review of the Principles of the Thwaites Flap, of the Design of Suitable Aerofoils and of Some Experimental Results. Brian Thwaites. *Royal Aeronautical Society, Journal,* Vol. 52, No. 446, February, 1948, pp. 117–124, diagrs. 2 references.

A summary of the principles and possible application to airfoils of the Thwaites flap. Experiments have shown that it is possible, independent of incidence, to produce circulation about a body in a uniform stream if a type of flap is provided which moves around a well-rounded trailing edge and if continuous suction is applied through this edge. Airfoils with such a flap could be designed to function at zero incidence and would enable aircraft to fly in a constant attitude. By correct design, laminar flow could be achieved over twice as large a portion as with conventional airfoils, so that not only high lift coefficients would be achieved but also the lift of the two main planes could be varied independently.

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The low maximum velocity that might be obtained would ensure a high critical Mach Number and, since, if such a flap were to be wholly retracted, there would be no change in circulation, the effect of gusts would be reduced.

Problèmes Non Linéaires de la Théorie de l'Aile: La Determination du Maximum de Portance (Nonlinear Problems of Wing Theory: The Determination of Maximum Lift). J. Pérès, L. Malavard, and L. Romani. *Groupement pour le Développement des Recherches Aéronautiques (G.R.A.), Rapport Technique No. 20,* 1946. 76 pp., figs., tables. 5 references. (In French.)

Pressure-Distribution Measurements of Two Airfoil Models With Fowler Flaps Submitted by Consolidated Aircraft Corporation As Alternative Wing Sections of the XP-32 Airplane. Ira H. Abbott. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-700),* January, 1942. 38 pp., figs. 2 references.

Airplane Design & Description (10)

Unified Design for Performance and Safety Characteristics. Frederick W. Ross. *Aeronautical Engineering Review,* Vol. 7, No. 5, May, 1948, pp. 22–29, 84, illus., diagrs. 2 references.

The criterion by which the design elements are selected in this method is a rating based on their contribution to both the performance characteristics and the safety characteristics of the airplane. Statistical data were used to establish a weighting factor for the safety characteristics of the various design components. These factors were plotted against each other on a chart to facilitate the selection of the optimum design of the various aircraft components. The process of development of a wing by this method is described. The airfoil-flap-aileron design obtained had improved stall characteristics and high performance rating. The extension of this method to the design of an entire aircraft is cited as an example of the advantage of an integral design approach.

Aircraft Design Procedure. I, II. R. L. Lickley. *Flight,* Vol. 53, Nos. 2045, 2046, March 4, 11, 1948, pp. 267; 288, 289, Discussion, p. 290, diagrs.

A detailed history of the growth of an airplane design from the preliminary statement of user's requirements to the final prototype. During each stage of the development the functions to be performed by each section of the firm are explained, with indication of those activities that are concurrent and those that follow in sequence. The difficulties that must be compromised by the participants in the many conferences attending this development show many of the sources of delay that make such a project so time-consuming.

The Design Evolution of an Aeroplane. R. L. Lickley. *The Aeroplane,* Vol. 74, No. 1918, March 12, 1948, p. 302.

Casual Commentary. Robert Carling. *Flight,* Vol. 53, No. 2044, February 26, 1948, pp. 233, 234.

The pressure of speeded-up development has produced aircraft layouts that do not conform with the natural characteristics of airplanes. The high drag caused by leading-edge engines and propellers and the adverse effects of the resultant asymmetrical slipstream could be eliminated by a design using a pusher propeller and control surfaces located forward.

Data for the Design of Smooth Wing Surfaces. D. M. A. Leggett. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2193,* January, 1944. 14 pp., diagrs. 3 references. British Information Services, New York. $1.00.

A theoretical analysis shows that for the design of laminar-flow wings there exists certain restricted ranges of skin thickness, stringer spacing, and rib spacing in which stressed-skin construction can provide the required degree of smoothness. For a two-spar wing with spanwise stringers and ribs at conventional spacing, an efficient combination is 16-gage skin with stringers at 4-in. pitch or 14-gage skin with stringers at 5-in. pitch. Theory indicates that a two-spar wing in which the reinforcement is chordwise is not a type of construction well adapted for bombers. However, for fighters a 14-gage skin and chordwise reinforcement at 6-in. spacing is suggested.

Investigation of Means for Extending the Range of Several Bombers to 6000 Miles. H. S. Ribner and S. M. Harmon. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-591),* July, 1942. 34 pp., diagrs. 8 references. Calculations were made to establish the dimensions and loading of a trailer or single glider and of twin outboard gliders and the bomber loading that would be required.

Building Commercial Aircraft. V. H. Patriarche. *The Aeroplane,* Vol. 74, No. 1913, February 6, 1948, pp. 167, 168, illus.

A discussion of the methods by which air transport may be put on a self-sufficient commercial basis. The most promising avenue of approach is not the reduction of operating costs nor the increase of speed but rather the increase of pay load at present speeds.

The Kinematics of Undercarriage Retraction. H. G. Conway. *Royal Aeronautical Society, Journal,* Vol. 52, No. 446, February, 1948, pp. 125–137, diagrs.

A compilation of most of the known mechanical systems used for undercarriage retraction. In addition to the common methods, the 61 diagrams included show the geometries, both extended and retracted, of: linkages in which the shock absorber movement is an element; multilink and deformable quadrilateral mechanisms; retraction systems employing motion in two planes, rotation about the shock absorber axis or a hinged axle; contracting or extending shock absorber mechanisms; and self-breaking strut linkages.

Skis Expand Aircraft Activity In Winter and Broaden the Airplane's Utility. Arthur A. Bursch. *Aviation Maintenance & Operations,* Vol. 9, No. 3, February, 1948, p. 46, illus.

Engineering Aspects of the Development of the Rainbow. Alexander Kartveli. *Aircraft Engineering,* Vol. 20, No. 227, January, 1948, pp. 2–10, 20, illus.

What's Wrong With Our Airliners? James T. Bain. *Canadian Aviation,* Vol. 21, No. 1, January, 1948, pp. 26, 27, illus.

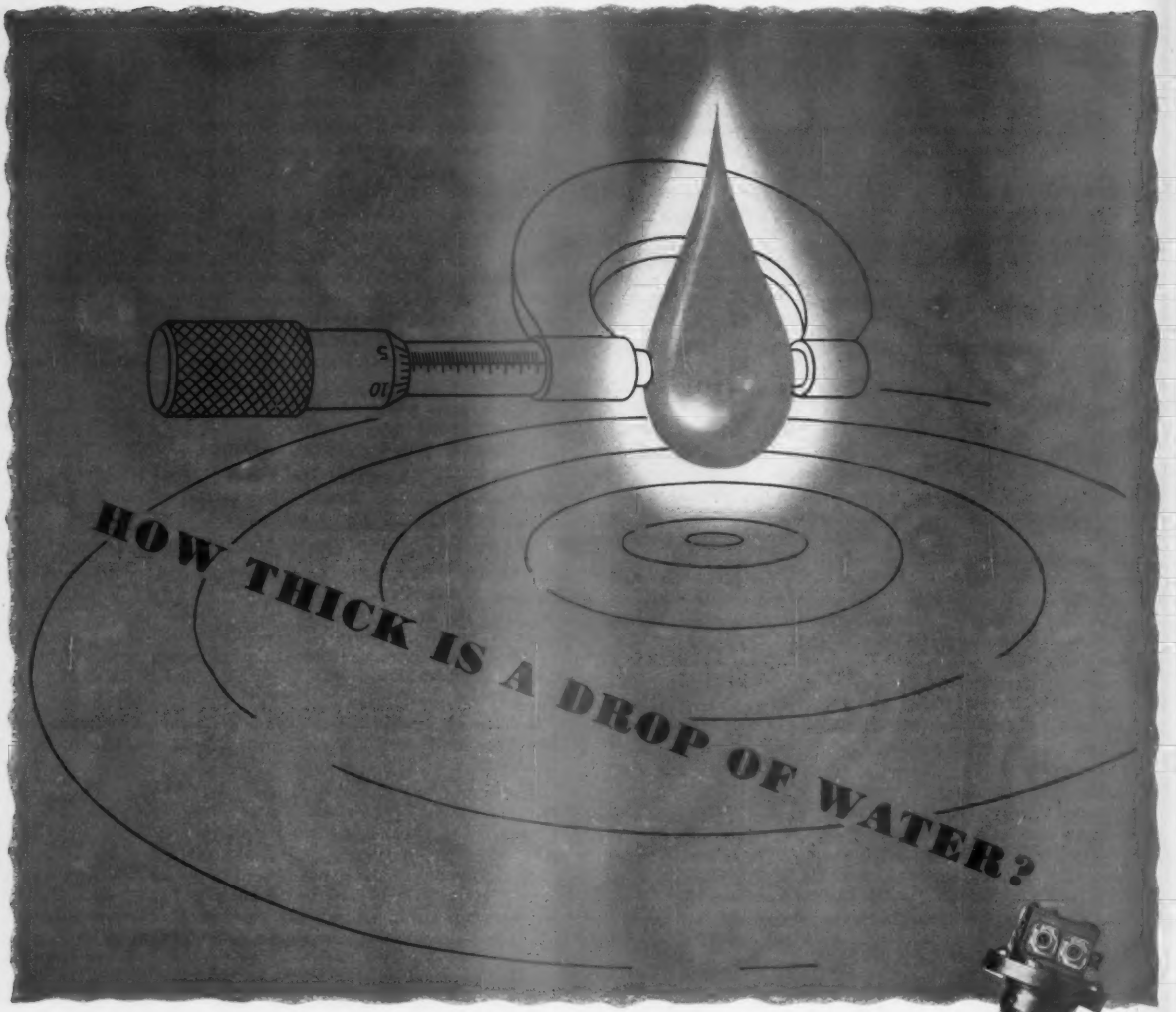
Wing with a Slant. Fred Hamlin. *Flying,* Vol. 42, No. 3, March, 1948, pp. 35, 83, illus.

According to the system developed by Earl Metzler, the wing dihedral of an Aeronca monoplane is altered during flight by means of a hydraulic extension unit installed in the base of the wing struts.

A Visitor's Impressions; Canada's Current Production and Plans for the Future. Royal Pearl. *Flight,* Vol. 53, No. 2048, March 25, 1948, 339, 340, illus.

The Biology of the Flying Saucer. I–IV. A. R. Weyl. *The Aeroplane,* Vol. 74, Nos. 1914, 1917, 1919, 1921, February 13, March 5, 19, April 2, 1948, pp. 185–187; 279–282; 337–339; 285–387; illus., diagrs., figs.

A history of the development and application of low-aspect aircraft wings from 1908 to the present date. The text is supplemented by illustrations and diagrams of the various models and by curves derived from wind-tunnel data obtained with this type of wing. **I.** Between 1908 and 1920 both British and German aircraft designers experimented with this type of wing and had observed its high lift characteristics at low incidence, the absence of stall below a 30° incidence, and the stability of the center of pressure below 18°. **II.** From 1913 to 1934 similar development was carried out in France, Italy and the United States. Wind-tunnel investigations were made in Germany and by Charles H. Zimmerman of the N.A.C.A. in America which formed the basis of subsequent developments. **III.** The most recent applications of this airfoil principle have been to the design of the helicopter airplane, the "Helicoplane" for low-speed flight, and high-speed aircraft capable of flight in the transonic or supersonic speed regions. This trend has its origin in early Telsa patents and can be traced through the work of Dornier, Bendermann and Fokker. Patents obtained by Mr. Zimmerman in 1934–1935, subsequently purchased by Chance-Vought Aircraft Division of the United Aircraft Corp. and adopted by the U.S. Navy, culminated in the XF5U-1 which with a gas-turbine power plant is said to have a speed range up to 500 m.p.h. In 1937 German work began to follow similar lines and yielded the Me-262 fighter planes. At the close of hostilities the research program was in progress at the Oranienburg research airdrome under the direction of Lt. Col. Kinemeyer. This airdrome and the models and prototypes under development were acquired by the U.S.S.R. Among other items acquired were the development models for the solid-fuel athodyd program. **IV.** This program was initiated in 1939 by Alexander Lippisch who recognized the unique features of the low-aspect ratio wing. In 1944 an experimental glider embodying the Lippisch wing was built and flown. Its failure to approach expected performance was attributed to the excessive structural weight that was a result of crude construction. The delta wings appear to be the means of solving the problems of both low-speed and transonic flight. The research of both von Kármán and W. G. A. Perring indicates that conventional control surfaces will become ineffective above Mach 0.92 or 0.93. This points to the



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need for a radical departure in the design of control systems before the full potentialities of the low-aspect-ratio or the disc wing can be realized.

The Flying Auto Problem. J. M. Gwinn. *Flying*, Vol. 42, No. 3, March, 1948, pp. 18, 79, 80, illus.

Chronicles of Jet Propulsion. III—V Germany. *The Aeroplane Spotter*, Vol. 9, Nos. 206, 207, 208, February 7, 21, March 6, 1948, pp. 34; 46; 58, illus.

1948 Transport Aircraft Directory. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 20–22, 24, 26, 28, 30, 31, illus. Specifications and performance of 18 U.S., Canadian, and British aircraft. Some prices.

1948 Annual Directory of Personal Aircraft. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 34–36, 38, 40, 42, 44, 46–48, illus. Specifications, performance, and prices of 47 aircraft.

American Commercial and Private Aircraft; British Commercial and Private Aircraft. *Automotive Industries*, Vol. 98, No. 5, March 15, 1948, pp. 152, 153. Two tables listing specifications and performance of 78 models.

Twenty Years After; A Review of British Light Aircraft, 1927–1947. D. A. S. McKay. *Aeronautics*, Vol. 18, No. 3, February, 1948, pp. 36–38, diagrs.

Bombers of the Powers; British, American and Russian Types: The Lincoln Our Latest: Brabazon-Size Bombers in Production. *Flight*, Vol. 53, No. 2045, March 4, 1948, pp. 252–254, illus.

New Shapes in the Air: Mikoyan and Gurevich (MIG) (Twin-Jet Single-Seat Fighter) and Alexander Yakovlev (YAK) (Single Seat Jet Fighter). *The Aeroplane Spotter*, Vol. 9, No. 208, March 6, 1948, p. 53, illus.

Soviet Transports; TU-70 Liner is B-29 Copy, with Minor Changes; IL-18 and 12 also Analyzed. *Aviation Week*, Vol. 48, No. 9, March 1, 1948, pp. 24, 25, illus.

New Shapes in the Air; Aerosudouest SO 30R-2 Bellatrix and the Praga E 211. *The Aeroplane Spotter*, Vol. 9, No. 206, February 7, 1948, p. 29, illus.

Tempest and Spitfire: The Hawker Tempest and The Supermarine Spitfire. *The Aeroplane*, Vol. 74, No. 1913, February 6, 1948, p. 154, illus.

U.S. Military and Civil Transports: Budd Conestoga and Martin Mariner. *The Aeroplane*, Vol. 74, No. 1917, March 5, 1948, p. 270, illus.

Dauntless and Commando: The Douglas Dauntless and the Curtiss Commando. *The Aeroplane*, Vol. 74, No. 1918, March 12, 1948, pp. 304, illus.

New Shapes in the Air: The Fairey Primary Trainer and the de Havilland D.H. 98 Mosquito T.T. MK. 39. *The Aeroplane Spotter*, Vol. 9, No. 207, February 21, 1948, p. 41, illus.

Flying To-Day—USA: The Goodyear GA-2 Duck, the Puget Pacific Wheelair III-A, the Nelson Dragonfly, and the Volmer VJ-21. *The Aeroplane Spotter*, Vol. 9, No. 207, February 21, 1948, p. 40, diagrs.

An Hour at the Controls of "Star Leopard." Maurice A. Smith. *Flight*, Vol. 53, No. 2046, March 11, 1948, pp. 275–277, illus. Includes preliminary, take-off, landing, and postoperation check lists.

Flying The Auster Avis (Light Airplane). R. G. Worcester. *The Aeroplane*, Vol. 74, No. 1921, April 2, 1948, pp. 392, 393, illus.

On The Air Routes. IV—Aerosudest Se 161 Languedoc. *The Aeroplane Spotter*, Vol. 9, No. 207, February 21, 1948, p. 45, illus.

Tschechisches Touristik- und Taxiflugzeug "Aero 45" (Czech Touring and Taxi Airplane Aero 45). *Schweizer Aero-Revue*, Vol. 23, No. 1, January, 1948, pp. 18–20, illus.

More About Tudors; The Atmosphere at Chadderton; Modifications; B.O.A.C. Mk. IVB.; Other Marks. *Flight*, Vol. 53, No. 2046, March 11, 1948, pp. 285–287, illus.

The Tudor IV (Transport). *The Aeroplane*, Vol. 74, No. 1916, February 27, 1948, pp. 253–255, illus. General description including some performance characteristics.

Four-Seat Auster; Introduction and Demonstration of the Avis; Gipsy Major X Engine. *Flight*, Vol. 53, No. 2048, March 25, 1948, pp. 336–338, cutaway drawing.

Avro's Mamba-Athena. *The Aeroplane*, Vol. 74, No. 1920, March 26, 1948, pp. 354, 355, 362, 363, illus.

Swept Wing Taxes Piloting Skill: Bell- L-39, First U.S. Swept Wing Airplane, Is Test Vehicle in Effort to Develop Essential Data for Our High Speed Fighters. Robert McLarren. *Aviation Week*, Vol. 48, No. 10, March 8, 1948, p. 30, illus.

The Boeing Stratocruiser Transport. II. A. Marthason. *The Aeroplane*, Vol. 74, No. 1916, February 27, 1948, pp. 248–251, diagrs. (Cf. AER 5/48:46.) The space distribution, appointments, and accommodations, the pressurized structural design, and hermetic sealing of the Boeing Stratocruiser.

Bristol's New Type 170 (Transport). *The Aeroplane*, Vol. 74, No. 1915, February 20, 1948, pp. 220–222, illus. Contains table of propeller propulsive thrust and charts of true air speed, still air range, and rate of climb.

Flying the Bristol Wayfarer (170). R. G. Worcester. *The Aeroplane*, Vol. 74, No. 1915, February 20, 1948, pp. 222–224, illus.

Flying the (Beech) Bonanza. R. G. Worcester. *The Aeroplane*, Vol. 74, No. 1915, February 20, 1948, pp. 215, 216, illus.

New Bristol 170 (Transport). *Flight*, Vol. 53, No. 2043, February 19, 1948, pp. 205–208, illus.

Engineering Facts about the World's Largest Landplane (Consolidated Vultee XC-99). *Automotive Industries*, Vol. 98, No. 1, February 15, 1948, pp. 42, 43, 58, illus.

Flying the (de Havilland (Canada) DHC-1) Chipmunk. D. A. S. McKay. *Aeronautics*, Vol. 18, No. 2, January, 1948, pp. 52, 53, illus.

On the Air Routes. V—de Havilland Dove. *The Aeroplane Spotter*, Vol. 9, No. 208, March 6, 1948, p. 57, illus.

The Mosquito Target-Tug. *The Aeroplane*, Vol. 74, No. 1913, February 6, 1948, pp. 165, 166, illus.

Skyrocket; Turbo-Jet and Liquid-Rocket Power in Douglas Trans-Sonic Research Aircraft. *Flight*, Vol. 53, No. 2041, February 5, 1948, pp. 147–149, illus.

Flying the Fairey Primary Trainer. *The Aeroplane*, Vol. 74, No. 1913, February 6, 1948, p. 158.

Fairey Primary Trainer; Two-Seater with Some Unusual Features: Gipsy Major 10 Engine. *Flight*, Vol. 53, No. 2041, February 5, 1948, p. 139, diagr.

Fairey (Primary) Trainer in the Air: Four-Blade Airscrew, Cartridge Starter, Good Low-Speed Characteristics. Maurice A. Smith. *Flight*, Vol. 53, No. 2042, February 12, 1948, pp. 167, 168, illus.

Italian Airframes—Rolls-Royce Engines: Fiat G.55 AM and Fiat G.55 BM. *The Aeroplane*, Vol. 74, No. 1908, January 2, 1948, p. 6, illus.

Goodyear Duck: Metal Three-Seat Amphibian With Pleasant All-Round Handling Characteristics. *Flight*, Vol. 53, No. 2047, March 18, 1948, pp. 307, 308, illus.

Flying The Trent-Meteor. R. G. Worcester. *The Aeroplane*, Vol. 74, No. 1920, March 26, 1948, pp. 365–367, illus.

Trent Meteor "In the Air"; First Experience of Airscrew-Turbines; Pitch and Jet-Pipe Temperature Control for Economy. Maurice A. Smith. *Flight*, Vol. 53, No. 2047, March 18, 1948, pp. 299–301, illus.

Universal Transport; Economy and Strength Characterise the New G.A.L. 60 Freighter. *Flight*, Vol. 53, No. 2041, February 5, 1948, pp. 150–154, illus.

The World's Fastest Trainer (Gloster Meteor). *Flight*, Vol. 53, No. 2042, February 12, 1946, pp. 192, cutaway drawing.

Unveil (Lockheed) Constitution's Design Highlights. *Aviation Week*, Vol. 48, No. 9, March 1, 1948, pp. 20, 21, illus. Illustrations of engine mounts, wind tunnel pressurized bulkhead, and tail details; also cargo handling, cabin heating, and features facilitating maintenance.

Latécoère 631 (Flying Boat). *Aeronautics*, Vol. 18, No. 2, January, 1948, pp. 46–49, illus.

German Jets That Were Operational: Messerschmitt Sturmvogel and Messerschmitt Komet. *The Aeroplane*, Vol. 74, No. 1916, February 27, 1948, p. 252, illus.

Arctur Flying-Wing Project. Leopold Harbich. (*Me/Arctur/1*, February, 1946.) *U.S., Air Force, Translation No. F-TS-789-RE*, February, 1948. 37 pp., illus.

Design description with analysis of component structural parts and performance data of a tailless, narrow-wing, high-speed touring airplane. A turbojet power plant, TM 32, of the barrel type developed by Staatz, has a fuel consumption of 0.0877 lb. of commercial nonleaded gasoline per hp.-hr. and a consumption of 0.00179 lb. of motor oil per hp.-hr. A landing-gear power drive that cuts out at a forward speed of 15.5 m.p.h. is provided to compensate for the low static thrust of the jet power plant. Wing and fuselage are of metal or wood monocoque construction. The wooden construction employs a double skin joined by separating

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shear elements called "sheer spools." Each of the three landing gear struts contains a transmitting element that controls an indicator on the instrument panel to show the load sustained by each. This provides data from which the pilot can calculate directly the total take-off weight of the airplane and the location of the center of gravity. Two alternative propeller-driven models are also described.

Potted History. I—Percival Aircraft Limited. *The Aeroplane Spotter*, Vol. 9, No. 206, February 7, 1948, pp. 30–32, illus. Includes a table of specifications of Models P. 1 to P. 50B.

Thunderjet (Republic P-84)—Air Force Ace For '48. Nathaniel F. Silsbee. *Aero Digest*, Vol. 56, No. 2, February 1948, pp. 44–48, illus., cutaway drawings.

For Continental Routes; Latest Version of the French SO "Bellatrix." *Flight*, Vol. 53, No. 2043, February 19, 1948, p. 213, illus.

Progress of the SR/45 Flying Boat. *The Aeroplane*, Vol. 74, No. 1913, February 6, 1948, pp. 160–164, illus., cutaway drawings.

Die Französischen Schul- und Touristikflugzeuge "SIPA" S-90 und S-91 (The French Training and Touring Airplanes SIPA S-90 and S-91). *Schweizer Aero-Revue*, Vol. 22, No. 12, December, 1947, p. 504, illus.

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Analysis of Air Traffic at Kingsford-Smith Airport, Sydney. R. B. Coulson. *Australia, Council for Scientific and Industrial Research, Division of Radiophysics, Report No. RPR 26*, July, 1947. 37 pp., figs. The information obtained is illustrated by a statistical analysis of rate of arrival, circuits and procedures, and the time taken for a circuit.

New Instrument Approach and Holding Procedures. *The Aeroplane*, Vol. 74, No. 1919, March 19, 1948, pp. 340, 341, illus., diagrs. A summary of the standardized instrument approach and holding procedures recommended by a committee of the Ministry of Civil Aviation.

Landing in The Dark Using V-Technique. R. G. Worcester. *The Aeroplane*, Vol. 74, No. 1916, February 27, 1948, pp. 245–247, illus. Description of test installation of runway marker lights at the R.A.F. Lakenheath airport.

High Intensity Runway Lighting. Leslie C. Vipond. *Airports*, Vol. 13, No. 2, February, 1948, pp. 16, 17, 31, illus.

All-Weather Approach Lighting. W. A. Pennow. *Aviation Maintenance & Operations*, Vol. 9, No. 3, February, 1948, pp. 30–32, 86, 88, illus. Details of the lighting system used at the Cleveland Municipal Airport. Includes table of weather conditions, the settings of the approach line lights, and their minimum penetration.

Recipe For Airport Revenue. Robert S. Curtiss. *Aviation Maintenance & Operations*, Vol. 9, No. 1, December, 1947, pp. 21, 22, illus.

Plans of the Port of New York Authority for developing the nonflight revenue-producing installations at New York International Airport, Idlewild. This project is part of the Authority's overall plan to integrate New York International, La Guardia, and Newark Airports into a self-supporting, unified, airport system.

Layout of Airport Buildings. II. J. W. S. Brancker. *Modern Transport*, Vol. 58, No. 1509, February 28, 1948, p. 7.

All-Weather Flying (31)

ICE PREVENTION

De-Icing Effectiveness of External Electric Heaters for Propeller Blades. James P. Lewis. *U.S., N.A.C.A., Technical Note No. 1520*, February, 1948. 95 pp., illus. 4 references.

Icing protection provided by external rubber-clad propeller blade heaters at several icing, heating, and propeller operating conditions has been determined. Effects of propeller speed, ambient-air temperature, liquid water concentration, heating power density, duration of heating, and total cycle time on power requirements and de-icing performance were investigated. Power densities of $4^1/_2$ to 10 watts per sq.in. were required for cyclic de-icing with best chordwise distribution approaching uniformity. Heating times of approximately 24 sec. were required with ratio of heat-on to total cycle time of 1:4 giving best results. Mean rate of rise of heater temperature of approximately 1.1°F. per sec. was obtained.

Cold Facts: Canadian N.R.C. Report on Icing in Turbines. *Flight*, Vol. 53, No. 2048, March 25, 1948, pp. 322, 323, illus.

Aviation Medicine (19)

Tolerance to Vertical Acceleration Required for Seat Ejection. D. T. Watts, E. S. Mendelson, H. N. Hunter, A. T. Kornfield, and J. R. Poppen. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 554–564, Discussion, pp. 564, 616, 618, illus. 8 references.

Test facilities, procedure, and instrumentation. Subjects tolerated repeatedly a maximum acceleration of 18*g* to 21*g* with no significant injury and with a minimum of discomfort. Detailed analysis was made of the dynamic response of the seat-cushion-subject mass to the suddenly applied ejection force.

Human Tolerance to Acceleration in Pilot Ejection. W. H. Ames, H. M. Sweeney, and H. E. Savely. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 548–553, illus. 4 references.

The design of a pilot-ejection seat and catapult equipment that develop a terminal acceleration of 60 ft. per sec. and apply loads of from 14*g* to 16*g* to the pilot. Subjective reactions during tests are summarized.

The Effect of Anoxia on Retinal Vessels and Retinal Arterial Pressure. J. Duguet, Pierre Dumont, and Jean-Pierre Bailliart. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 516–520, illus. 3 references.

An Appraisal of Intermittent Pressure Breathing as a Method of Increasing Altitude Tolerance. Morris Eckman, Beatrice Barach, Charles Fox, Charles C. Rumsey, Jr., Eugene Somkin, and Alvan L. Barach. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 565–574, Discussion, pp. 574–576, tables. 7 references.

Studies on Asphyxia. II—Effects of Carbon Dioxide Inhalation on an Anoxic Animal. John H. Ivy, Fred S. Grodins, Harry F. Adler, and Forrest E. Snapp. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 577–589, 622, illus. 13 references.

Psychological Requirements of the Airplane Pilot. John C. Flanagan. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 521–527, Discussion, pp. 527, 600, charts. 7 references.

Visual Standards and Flight Performance. Morris S. Viteles. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 528–546, Discussion, pp. 546, 547, figs. 16 references.

Food Preferences on Combat Flights. David Bruce Dill. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1948, pp. 590–593, Discussion, p. 593. 1 reference.

Distance Discrimination. V—Effect of Motion and Distance of Targets on Monocular and Binocular Distance Discrimination. Monroe J. Hirsch and Frank W. Weymouth. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 594–600, figs. 7 references.

Air Evacuation; An Historical Review. Frederick R. Guilford and Burton J. Soboroff. *Journal of Aviation Medicine*, Vol. 18, No. 6, December, 1947, pp. 601–616, illus. 26 references.

Time Saving Techniques of Psychotherapy. Ernest L. MacQuiddy. *Contact* (U.S. Naval School of Aviation Medicine and Research, Pensacola, Fla.), Vol. 6, No. 4, January 1, 1948, pp. 247–259. 36 references.

The Etiology of Aeroembolism and Aeroemphysema and Hyperventilation as a Prophylactic and Therapeutic Measure. Alan F. Thometz. *Contact* (U.S. Naval School of Aviation Medicine and Research, Pensacola, Fla.), Vol. 6, No. 4, January 1, 1948, pp. 237–246, figs. 9 references.

An Investigation of the Learning of Stall Perception. F. C. Dockeray and David Bakan. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 75*, February, 1948. 51 pp., illus.

A report on the effectiveness of training on stall recognition. A group of private pilots, each of whom had had a maximum of 5 hr. flying experience, was given special training in stall perception. In a series of tests their ability to bring the aircraft to the verge of the stall was compared with the performance in similar tests of a control group of pilots each of whom had had more than 40 hr. of experience but who had been given no special training in stall detection. The results indicated that the accuracy of stall perception could be improved by training and that the proficiency obtained in the maneuvers in which training was given was transferred to other maneuvers and situations in which no explicit training had been given.

Comfortization (23)

Passenger Service Requirements for North Atlantic Operations. J. W. Schwab. *The Engineering Journal*, Vol. 31, No. 1, January, 1948, pp. 21–24.

A discussion of the experience of Trans-Canada Air Lines in transatlantic operations with reference to seating, air conditioning, noise, lighting, styling, wash rooms, entertainment, catering, safety devices, and the selection of steward personnel.

Cabin Pressurization is the Key to High Speed, High Level Flight. *Aircraft and Airport*, Vol. 10, No. 1, January, 1948, pp. 22–24, illus. The pressurization system of the Canadair Four.

Stratocruiser Water System Discussion (Boeing 377). *Boeing Service Guide*, No. 6, March, 1948, pp. 2–7, diagrs.

Education & Training*

Special Education Issue. *Air Affairs*, Vol. 2, No. 2, Winter, 1948, pp. 161–277, diagr.

Electronics (3)

Daylight Display Plotting System, Mk. I & Mk. II. T. D. Newnham. *Australia, Council for Scientific and Industrial Research, Division of Radiophysics, Report No. RPR 68*, September, 1947. 41 pp., illus., diagrs.

A system for presenting information obtained from the plane-position indicators of approach-control and airways-control radars. The aircraft tracks on the display screen are plainly visible from a distance of about 30 ft. in a normally lighted room. This report contains design information supplementary to Reports Nos. RPR 31 and 56.

Approach Control Radar at Mascot. E. K. Inall. *Australia, Council for Scientific and Industrial Research, Division of Radiophysics, Report No. RPR 56*, February, 1947. 67 pp., illus., diagrs. Modification of a 717B radar for use in approach control, its installation, and instructions for care and operational maintenance. Details of daylight display are included.

Airline Trials of Distance Measuring Equipment and of the Multiple Track Radar Range; Technical Aspects of Tests Made over the Sydney-Melbourne Air Route, January–May, 1947. J. G. Downes. *Australia, Council for Scientific and Industrial Research, Division of Radiophysics, Report No. RPR 79*, October, 1947. 60 pp., illus., diagrs.

Test Equipment for Multiple Track Range. E. B. Mulholland. *Australia, Council for Scientific and Industrial Research, Division of Radiophysics, Report No. RPR 59*, February, 1947. 91 pp., illus., diagrs.

Design, circuits, and operation of the crystal calibrator (oscillator) unit, calibrator time-base unit, radio-frequency calibrator unit, test (phase-shift) oscillator, and monitor receiver. These units are interim equipment developed to test the Multiple Track Range Mk. I installation. Detailed testing procedure given for the master, slave, and air-borne installations.

Airways Control Radar (Interim Report). R. F. Treharne. *Australia, Council for Scientific and Industrial Research, Division of Radiophysics, Report No. RPR 18*, April, 1946. 39 pp., illus., diagrs. 5 references. Survey of existing airways and airport traffic-control facilities and procedure. Two airways control radar sets, AWC-I and AWC-II, now under development, are discussed in detail.

Preliminary Flight Tests of an Orbiting Equipment. E. B. Mulholland. *Australia, Council for Scientific and Industrial Research, Division of Radiophysics, Report No. RPR 73*, November, 1947. 33 pp., figs.

Records of initial flight tests of an orbiting attachment to a standard Australian distance-measuring equipment. The two pilots whose flights were recorded were both inexperienced in instrument flying and showed average departures of 130 yards and 65 yards.

Visual Photometer for After-Glow Tests on Cathode-Ray Tube Screens. W. G. White. *Journal of Scientific Instruments*, Vol. 25, No. 1, January, 1948, pp. 1–4, diagrs.

Bendix Products

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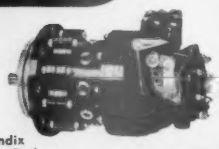

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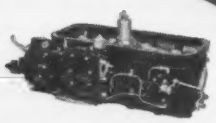

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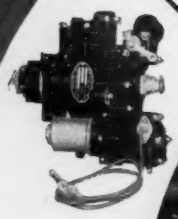

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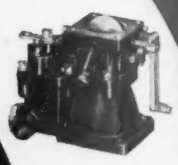
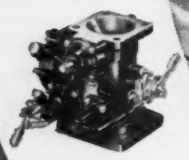
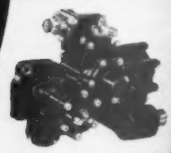


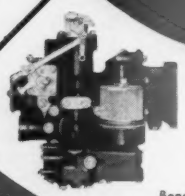
Stromberg Float Type Carburetor.



Stromberg* Injection Carburetor for personal planes.



Regulator for Stromberg Water Injection Control System.



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The Visibility of Small Echoes on Radar PPI Displays. Ruby Payne-Scott. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 2, February, 1948, pp. 180–196, illus. 7 references.

Watchdog in the Cockpit. *Flying*, Vol. 42, No. 3, March, 1948, pp. 30, 31, illus.

The Allison radar is a complete tracking unit and scanner developed from the military APS-10. It provides terrain and obstacle warning by giving a complete picture of the terrain and sky at optional ranges of 150, 50, 15, or 5 miles on a 6-in. cathode-ray tube in the cockpit.

Magic Airway. Gaither Littrell. *Flying*, Vol. 42, No. 3, March, 1948, pp. 28, 29, 74–77, illus. The General Electric electronic Tricon system for air-traffic control.

Radio Builds Railroad In the Sky. Devon Francis. *Popular Science*, Vol. 152, No. 3, March, 1948, pp. 140–144, illus.

A description of the operation and the principal features of the TRIple COincidence Navigation System, TRICON (General Electric Co.), and the Minneapolis-Honeywell B-D Computer Aerial Navigation System.

Black Aircraft Experiments With Radar Countermeasures and Applications. Pigge. (*Opta Radio A.G., Leipzig, Mx/OR/11*, January, 1944.) *U.S., Air Force, Translation No. F-TS-849-RE*, February, 1948. 7 pp., diagrs.

A Variable-Radio-Frequency-Follower System. R. F. Wild. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 2, February, 1948, pp. 281–289, illus.

System design, performance data, and experimental and production models are described. The two parallel-resonant circuits provide low-frequency keying of the radio frequency signal before it is applied to the frequency discriminator, so that a low-frequency-discriminator output signal of one phase or opposite phase, depending on the direction of system unbalance, is obtained. The low-frequency signal is used to control a two-phase induction motor which drives the follower.

A Note on Frequency Transformations for Use with the Electrolytic Tank. W. H. Huggins. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 3, March, 1948, pp. 421–424, figs. 4 references.

Marconi Lightweights; Post-War Progress in British Airborne Equipment. *Flight*, Vol. 53, No. 2042, February 12, 1946, p. 186, illus.

A New Medium Wave Transmitter (Redifon Model G. 54); P. V. Design for Radio Communication and Navigational Service. *Airports & Air Transportation*, Vol. 2, No. 57, February, 1948, pp. 302, 303, illus.

German Automatic-Tuning Devices. II—The FBG-213 Radar-Receiver Tuning System (Project No. LE-26). J. S. Summerhayes. *U.S., Air Force, Technical Report No. F-TR-1159B-ND*, March, 1948. 9 pp., illus. Description and design details of the FBG-213 remote-control tuning system used with the FUG-220 (Lichtenstein SN2) radar receiver.

Electrical Absorbing Material. J. Jaumann. (*Frankfurt am Main-Hoechst, EIS/KRI/6*, February, 1944.) *U.S., Air Force, Translation No. F-TS-4626-RE*, January, 1948. 6 pp. 8 references.

A theoretical investigation of the reflection and absorption characteristics of radio waves. Radar countermeasures require the development of materials that will completely absorb radio waves. The dimensional parameters are developed for multilayer materials in which the progressive increase in absorptance of each layer results effectively in no wave reflection.

Accidental Firing of Flash Bulbs By Radar. A. D. Keogh. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 7, April 1, 1948, pp. 7–10, illus.

Radar beams of approximately 10-cm. wave length were found to be the most active in igniting flash bulbs. Two per cent of the bulbs tested exploded, shattering the glass and constituting a serious fire hazard.

Theory and Techniques of Antennas. II—Broad-Band Antennas, Transformers, and Cables. O. Zinke. (*IP 3936*, March, 1943.) *U.S., Air Force, Translation No. F-TS-2223-RE*, February, 1948. 220 pp., illus. 43 references.

A collection of 17 papers: Fundamentals of Wide-Band Antenna Installations, O. Zinke. Experimental Investigations on Flat and Pipe Dipoles as Wide Band Antennas, L. Pungs and K. Lamberts. The Influence of the Reflector Wall on the Locus Curve of Wide-Band Pipe Dipoles, G. Dieckmann. Application of Thick Antennas, Especially Grids in the Short Wave and Ultra-Short Wave Range, P. Kotowski and E. Schuettloeffel. Compensation of Dipole-Antennas at the Base Point, W. Buschbeck. Matching Problems, Test Arrangement and Design of Wide-Band Dipole Antennas, K. Fraenz. Rotating Wide-Band Dipole "Breitbein," W. Pauls. Design of a Wide-Band High-Power Antenna, H. Kaufmann. Wide-Band Antennas for Long Waves, H. Brueckmann. Dielectric Directional Antennas for Dm and Cm Waves, P. Mallach. Investigations on Parabolic Surface Antennas, Albert Weissfloch. Calculation and Design of Wide-Band Line Transformers, W. Pauls. Energy Transmission Lines and Matching, H. Roder. Recent Experiences of the German Postal Services with Feeding of Antennas for Long and Short Waves, Ellrodt. The Make-Up of the Attenuation for Concentric High Frequency Lines, O. Cords. General Problems of Hollow Conductor Cables, Buchholtz. Directions for the Uniform Designation of Antenna Magnitudes in Lectures and Reports, The Four-Year-Plan Institute for Oscillation Research.

Rainfall Intensities and Attenuation of Centimeter Electromagnetic Waves. Raymond Wexler and Joseph Weinstein. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 3, March, 1948, pp. 353–355, figs. 8 references.

Developments in Radio Sky-Wave Propagation Research and Applications During the War. J. H. Dellinger and Newbern Smith. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 2, February, 1948, pp. 258–266, diagrs.

The Place of Radio in Civil Aviation. I, II. P. F. Duncan. *The Aeroplane*, Vol. 74, Nos. 1914, 1915, February 13, 20, 1948, pp. 195–197; 225–227; illus. A survey with a detailed description of the communication, navigation, and landing-aid facilities at the London and Northolt airports.

Light Planes on the Air. Bill Corfield. *Canadian Aviation*, Vol. 21, No. 1, January, 1948, pp. 16, 17, 46, illus. Suggestions for selecting radio equipment for the personal plane.

Das Problem der Funkhilfen für Sport- und Touristikflugzeuge (The Problem of Radio Aids for Sport and Touring Airplanes). *Schweizer Aero-Revue*, Vol. 22, No. 12, December, 1947, pp. 517, 518.

Printed-Circuit Techniques. Cledo Brunetti and Roger W. Curtis. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 1, January, 1948, pp. 121–161, illus. 60 references.

Manufacturing Method for Making Metal-To-Glass Seals for Large Current Rectifier Electrodes (Project No. DE-73). Mueller. *U.S., Air Force, Technical Report No. F-TR-1175-ND*, March, 1948, 4 pp., illus.

Engineering Practices & Aids (49)

Conics as Applied to Mathematical Lofting. R. L. Morrison. *Aircraft Engineering*, Vol. 20, No. 228, February, 1948, pp. 46–50, 52, figs.

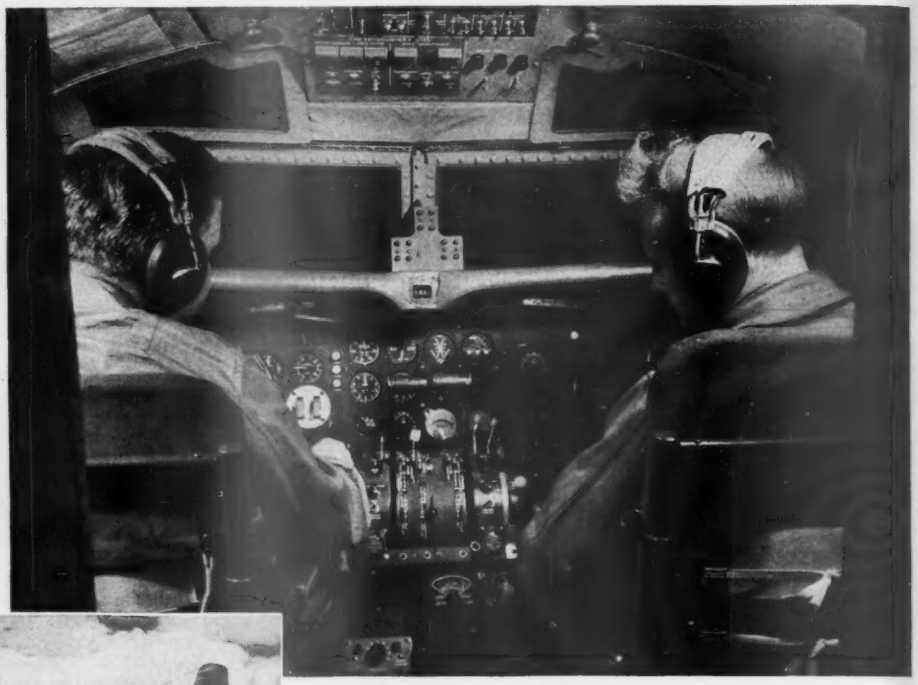
A procedure followed by Fleet Aircraft Limited. In order to permit the use of untrained personnel, a tabulation system was devised in which all the work is broken down into steps, each of which is numbered. Each step requires simple arithmetical operations. Formulas for the lines that are being sought are not given on the tabulation sheets, but the sequence and nature of the operations to be followed is indicated by reference to the preceding steps. Given numerical constants, electric calculators can be used to find the ordinates and abscissas of points on the design curve being sought. The method is given for developing these curves and slopes and offsets to them. An appendix shows the complete derivation of a second-degree curve suitable for aircraft use.

Equipment

HYDRAULIC & PNEUMATIC (20)

Hydraulic Motors and Pumps for Driving Accessories on Airplanes and Tanks. L. E. Bogue and Norman Hoertz. *U.S., Field Information Agency, Technical, Final Report No. 614*, February 12, 1946. 6 pp., diagrs. British Information Services, New York. $0.35.

Products of the Alfred Teves Company, Fechenheim, Germany. Two oil motors of 1.2- and 5-hp. capacity were developed to provide prerotation of aircraft undercarriage wheels upon landing. Each motor has a drum rotor containing nine oil-driven plungers that act parallel to the axis of rotation on a swash plate and develop a torque of 100 cm. per kg. The 5-hp. motor is designed



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to rotate at 4,000 r.p.m. A hydraulic pump employing a swash plate and plungers operates at 1,425 r.p.m. and can deliver from 1,900 to 2,100 cu.cm. per min. at 60 kg. per sq.cm.

Servodyne Aileron Control: Lockheed Unit for Large Aircraft. *Modern Transport*, Vol. 58, No. 1507, February 14, 1948, p. 9, illus.

Flight Testing (13)

A Recording Instrument for Performance Tests. Paavo Järvenpää. *Aircraft Engineering*, Vol. 20, No. 228, February, 1948, p. 35–37, 52, illus.

A photographic oscillograph that can simultaneously record air pressure, air speed, acceleration, cylinder-head temperature, air temperature, r.p.m., and booster pressure. A flight test to determine the effect of wing-tip slots on stalling speed and the appearance of flutter is used to illustrate the method of interpretation of the recorded data. Similar data obtained in speed tests may be used to obtain calibration curves for atmospheric pressure and temperature indicators.

Flight Vibration Tests. H. Borrow and H. Roos. (*ZWB/FB/1175/1-3*, February, 1940.) *U.S., Air Force, Translation No. F-TS-765-RE*, February, 1948. 128 pp., illus. 10 references.

The theoretical basis, method of testing, design of exciters and a recording instrument, and evaluation of results obtained with eight types of aircraft tested by the flight-vibration method. The danger inherent in determining the flutter speed of an aircraft by test flights and the ambiguity of the data so obtained made it necessary to develop a safe and reliable method. In flight vibration testing the components of an aircraft are excited during flight, and the natural oscillations so induced are measured at progressively higher flight speeds. An analysis of the resonance curves obtained makes it possible to identify the approach of the critical speed.

D.H. 108 Instrument Equipment. *The Aeroplane*, Vol. 74, No. 1914, February 13, 1948, p. 181, diagr.

Own Flight Test Section Operated by Rolls-Royce. *Aircraft and Airport*, Vol. 10, No. 1, January, 1948, pp. 30–32, illus.

Fuels & Lubricants (12)

Grease Lubricants for Gyroscope Motor. J. R. MacIntyre. *Aviation Maintenance & Operations*, Vol. 9, No. 3, February, 1948, pp. 28, 29, illus.

Six greases were selected on the basis of their physical properties (corrosion, bleeding and evaporation, oil viscosity, and consistency) to determine their suitability for gyroscope lubrication in view of the storage periods and the wide operating temperature range such lubricants must withstand. Cyclic tests to bearing destruction and cold-start tests show that grease lubrication of gyroscope-motor ball bearings is better than oil lubrication and that satisfactory cold starting can be maintained. A tabulation of the test results shows that little correlation exists between the measured physical properties of the grease and the life of the bearings. Thus, until other physical properties, as yet unknown, have been recognized, functional testing is necessary to select a satisfactory lubricating grease.

Lubrication of High Altitude Aircraft. A. A. Soderquist. *Shell Aviation News* (London), No. 115, January, 1948, pp. 14–18, illus.

The testing program used by the Boeing Aircraft Company in the selection of greases for extreme-temperature applications. A chart gives the specifications for five such special purpose greases and the method of testing each characteristic. The discussion includes the effect of various lubricants on synthetic-rubber bearing seals.

Knock-Limited Performance of Pure Hydrocarbons Blended With a Base Fuel in a Full-Scale Aircraft-Engine Cylinder. III—Four Aromatics, Six Ethers. Anthony W. Jones, Arthur W. Bull, and Edmund R. Jonash. *U.S., N.A.C.A., Advance Restricted Report No. E6B14* (*Wartime Report No. E-235*), March, 1946. 17 pp., figs. 2 references.

A Correlation of the Effects of Compression Ratio and Inlet-Air Temperature on the Knock Limits of Aviation Fuels in a CFR Engine. I. John C. Evvard and J. Robert Branstetter. *U.S., N.A.C.A., Advance Confidential Report No. E5D20* (*Wartime Report No. E-217*), May, 1945. 27 pp., figs. 4 references.

The Knock-Limited Performance of Several Miscellaneous Fuels Blended With a Base Fuel. Donald R. Bellman. *U.S., N.A.C.A., Advance Confidential Report No. E4G08* (*Wartime Report No. E-213*), July, 1944. 8 pp., figs. 1 reference.

Engine and Inspection Tests of Methyl *tert*-Butyl Ether as a Component of Aviation Fuel. Henry C. Barnett, Carl L. Meyer, and Anthony W. Jones. *U.S., N.A.C.A., Advance Confidential Report No. E4H03* (*Wartime Report No. F-214*), August, 1944. 29 pp., figs. 2 references.

Supercharged-Engine Knock Tests of Methyl *tert*-Butyl Ether. Henry C. Barnett and James W. Slough. *U.S., N.A.C.A., Advance Confidential Report No. E4H10* (*Wartime Report No. E-215*), August, 1944. 15 pp., diagrs.

Gliders & Gliding (35)

Segelflüge in Gewitterwolken (Soaring in Thunderheads). Walter Georgii. *Schweizer Aero-Revue*, Vol. 23, No. 1, January, 1948, pp. 14–16, diagrs.

1948 Annual Glider Directory. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 48, 49, diagrs. Descriptions, performance, and prices of 11 aircraft.

New Czech Sailplane; Pleasing Lines and High Performance of Zlin 25. *Flight*, Vol. 53, No. 2043, February 19, 1948, p. 216, illus.

Slingsby "Gull IV." *Sailplane and Glider*, Vol. 16, No. 1, January, 1948, pp. 5–6, illus.

Guided Missiles (1)

A 1943 Project; Test of Huge Supersonic Engineless Missile. *Flight*, Vol. 53, No. 2042, February 12, 1946, p. 169, illus.

A comparison of the athodyd-propelled missile that was flight-tested by the U.S. Navy Bureau of Ordnance and Bureau of Aeronautics with a proposal for a similar missile submitted to the Department of Scientific Research (Gt. Brit.) in 1943.

Why No Guided Missiles—Yet. Albert B. Scoles. *Aero Digest*, Vol. 56, No. 3, March, 1948, p. 67, illus.

Over 175 Miles Into Ionosphere: (Martin Neptune). *Plane Facts*, Vol. 4, No. 6, December, 1947, pp. 7, 8, illus.

History & Literature*

British Strategy in Two World Wars. Sir Robert Saundby. *The Aeroplane*, Vol. 74, No. 1918, March 12, 1948, pp. 297, 298.

The Strategic Bombing of Germany. Sir Norman Bottomley. *The Aeroplane*, Vol. 74, No. 1916, February 27, 1948, pp. 240, 241. (Summary of a paper.)

Hydrodynamics (21)

Tank Test of Three Types of Afterbodies on a Flying-Boat Model With Basic Hull Length-Beam Ratio of 10.0. Charlie C. Garrison and Eugene P. Clement. *U.S., N.A.C.A., Technical Note No. 1547*, March, 1948. 38 pp., diagrs. 6 references.

Three afterbodies were tested on a flying-boat model having a basic length-beam ratio of 10. The minimum depth of step required for adequate landing stability was 15.0 per cent of the beam for the constant-dead-rise afterbody, 13.0 per cent for the warped-dead-rise afterbody, and 21.8 per cent for extended warped-dead-rise afterbody. Satisfactory take-offs could be made over a range of position of the center of gravity of 9 per cent mean aerodynamic chord for the warped-dead-rise afterbody and 15 per cent mean aerodynamic chord for the other two afterbodies.

A Generalized Theoretical and Experimental Investigation of the Motions and Hydrodynamic Loads Experienced by V-Bottom Seaplanes During Step-Landing Impacts. Benjamin Milwitzky. *U.S., N.A.C.A., Technical Note No. 1516*, February, 1948. 60 pp., diagrs. 10 references.

The primary flow about the immersed portion of a keeled float or hull is considered to occur in transverse flow planes. The reaction of the water to the motion of the seaplane is calculated by means of the virtual-mass concept. The entire immersion process is analyzed from the instant of initial contact until the seaplane rebounds from the water surface. Conditions for impact similarity are discussed. The time histories of the motion and the hydrodynamics loads are calculated for a wide range of conditions extending from impacts along shallow flight paths approaching

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planing to impacts where the resultant velocity is normal to the keel. Solutions are presented for the state of motion and the time corresponding to the instants of maximum acceleration, maximum draft, and rebound from the water surface. The results are given in the form of dimensionless charts which may be used directly to determine the water loads and the motions of the seaplane at any instant during an impact as well as at the particular instants of maximum acceleration, maximum draft, and rebound.

Transports Today and Tomorrow. II—Large Flying Boats. H. F. King. *Flight*, Vol. 53, No. 2044, February 26, 1948, pp. 230a–230d, 231, 232, illus. A survey of current British, American, and French trends in design. Eight typical flying boats are sketched to a common scale to illustrate the variations in the hull.

Instruments (9)

A Pneumatic Method for Measuring High-Temperature Gases. David William Moore, Jr. *Aeronautical Engineering Review*, Vol. 7, No. 5, May, 1948, pp. 30–34, illus., diagrs.

The operation of the pneumatic method for measuring high gas temperatures is based on the well-known equations for the flow of gas through an orifice. Such equations are usually solved to determine the volume or the mass flow of the gas, but it is shown how they may be utilized to measure accurately and rapidly practically any gas temperature. The method is particularly applicable to the problem of measuring combustion gas temperatures in turbojet and turboprop power plants where both operating efficiency and safety are dependent upon the operating temperature. Various practical instruments are discussed, including those designed for ram-jet and rocket application. Measurement accuracy of better than 2 per cent has been achieved, and instruments are being manufactured to measure temperatures in excess of 5,000°R.

Review of Remote Indicating Systems for Aircraft Instruments. F. Postlethwaite. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2199*, April, 1945. 25 pp., diagrs. 22 references. British Information Services, New York. $1.45.

A critical survey of known and possible remote indicating systems suitable for use in aircraft. Over thirty-one systems are evaluated, including both a.c. and d.c. linear and limited angle transmitters, rotary motion remote transmitters, impulse and repeater-motor remote indicators, and hydraulic and pneumatic methods of remote indication. From an analysis of the basic principles, fundamental features, and a comparison of the various systems, it is concluded that electric operation offers the greatest promise not only for the transmission of unrestricted rotation but also for the development of an ideal system to handle all other remote indications.

Measurement of Ambient Air Temperature in Flight. W. Lavern Howland. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Paper No. 106*, 1947. 13 pp., diagrs., 10 references. $0.50.

Ambient air temperature has been difficult to measure accurately in flight because of radiation and conduction losses and the failure of the measuring unit to recover the velocity energy. A resistance bulb or thermocouple in the temperature probe described is housed in an insulating chamber in which the high velocity air is brought substantially to rest and protected from the cooling action of the main air stream. Above speeds of 100 m.p.h. the instrument stabilized in 2.5 sec. when a resistance unit was used and in a shorter time when a thermocouple was used. The instrument can be used to obtain the ambient air temperature during speed runs or climb tests by obtaining a number of speed points at known altitudes, plotting the observed temperature against the square of the velocity, and extrapolating a straight line through the points to zero velocity.

Metallurgical Examination of Two Japanese Aircraft Bank and Turn Indicators (BMI Nos. 556 and 558). L. R. Jackson, W. W. Beaver, and H. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1485.* 26 pp., illus. British Information Services, New York. $1.15.

The Control Equations and Locus Curves of Direction Controllers. Würthner. (*Siemens, Mx/LGW/77Lgl-A1002*, February 11, 1944.) *Cornell Aeronautical Laboratory, Translation*, October, 1947. 17 pp., diagrs.

The control differential equation is developed for a directional controller that comprises a bolometer directional gyro with lag, an inertialess turn indicator, and a servo control with inertia and feed-back coupling. The inertia lag of the direction indicator which is present in addition to the lag of the controls caused by the inertia of the servo motor is compensated by an acceleration coupling component that arises from the inertia of the directional gyro. The locus curve equations of the controller are given so that the time constants of the controller may be determined by comparison with empirical locus curves.

Turning Errors of a Monitored Directional Gyroscope. I, II. H. L. Price. *Aircraft Engineering*, Vol. 20, Nos. 227, 228, January, February, 1948, pp. 11–16; 38–45; figs.

A general analysis of the errors inherent in monitored gyroscopic direction indicators. The errors in pointer and level indication during the execution of a perfectly banked turn and pull-out and the residual errors after recovery are expressed as functions of the angle of bank, duration of the turn, and flight velocity. The inaccuracy introduced in the reading of the air position indicator by the residual error in direction indication which remains after recovery from a turn can be determined from the set of charts presented.

Gyrosyn Compass, Models C-2 and C-2A. *Sperry Gyroscope Co., Publication No. 15-38B*, December, 1947. 11 pp., illus. diagrs.

Function, operation, and specifications of the equipment and its parts. The Gyrosyn Compass is a directional gyro that is synchronized with the earth's magnetic meridian by means of a flux valve.

The Sperry A-12 Gyropilot. *The Aeroplane*, Vol. 74, No. 1921, April 2, 1948, pp. 390, 391, illus.

Introduction to the Electric Pilot (S.E.P.I.). C. Williams. *The Technical Instructor*, Vol. 3, No. 2, February, 1948, pp. 9–13, diagrs.

Smith Electric Auto Pilot. *Aircraft and Airport*, Vol. 10, No. 1, January, 1948, pp. 38, 39, illus.

Analysis of Accuracy of Gas-Filled Bellows for Sensing Gas Density. Edward W. Otto. *U.S., N.A.C.A., Technical Note No. 1538*, February, 1948. 29 pp., diagrs.

An analysis of the characteristics and the error of a gas-filled bellows for sensing gas density shows that a density-sensitive bellows gives an indication of density that is parametric with the conditions of temperature or pressure. The amount of error is roughly indicated by the ratio of the total force that the bellows must oppose to the area of the bellows. To ensure a minimum error, bellows for this application should be designed with as low spring rates as possible, and the output force required of them should be as low as possible.

Analysis of Engine Performance During Flight. John H. Jupe. *Aircraft Engineering*, Vol. 20, No. 228, February, 1948, pp. 51, 52, illus. The Sperry Engine Analyzer.

Turbo-Engine Thermocouples and Accessories. *Thermo Electric Company, Catalog, Aircraft Section No. 11*, 1948. 4 pp., diagrs.

Specifications of Chromel Alumel turbo-engine exhaust-gas thermocouples, paralleling harnesses for multiple thermocouples, lead wires, terminal and junction blocks, fire-wall disconnect plugs, and adjustable resistors.

Sailplane Instruments and Their Layout. T. R. Young. *The Aeroplane*, Vol. 74, No. 1921, April 2, 1948, pp. 401, 402, illus.

Laws & Regulations (44)

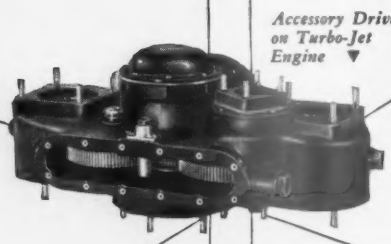
The Geneva Commission on a Multilateral Air Transport Agreement. Robert J. G. McClurkin. *Journal of Air Law and Commerce*, Vol. 15, No. 1, Winter, 1948, pp. 39–46.

State Sovereignty vs. Federal Sovereignty of Navigable Air-Space. John C. Cooper. *Journal of Air Law and Commerce*, Vol. 15, No. 1, Winter, 1948, pp. 27–38.

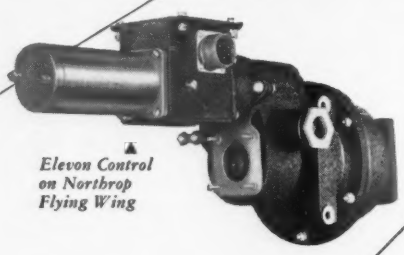
Maintenance (25)

The Planning of Aircraft Maintenance. R. E. J. White. *Aircraft Engineering*, Vol. 20, No. 227, January, 1948, pp. 28, 29, charts.

A method of computing the optimum maintenance force and the minimum number of aircraft required for operation of an airline schedule. A maintenance organization chart, a master maintenance schedule, and a sample work-progress record are illustrated.



Accessory Drive on Turbo-Jet Engine ▼



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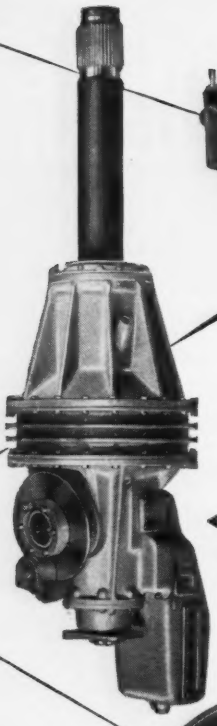
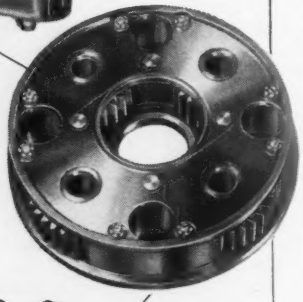


◀ Main Rotor Transmission on Sikorsky Helicopter



Planetary Transmission on Piasecki Helicopter ▶

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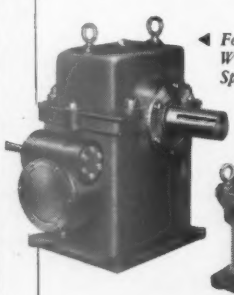

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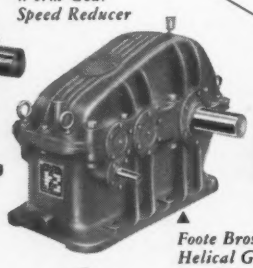
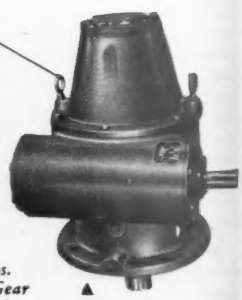


▲ Foote Bros. Helical Gear Speed Reducer



▲ Foote Bros. Vertical Speed Reducer

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Do's and Don'ts In Engine Maintenance. Gilbert C. Close. *Western Flying*, Vol. 28, No. 3, March, 1948, pp. 12, 13, 22, illus.

Planned Servicing; Spectacular Results from R.A.F. Manpower Economy Scheme. *Flight*, Vol. 53, No. 2048, March 25, 1948, pp. 327–330, illus.

The Care and Maintenance of K.L.G. Aviation Sparking Plugs. *The Technical Instructor*, Vol. 3, No. 2, February, 1948, pp. 3–8, diagrs.

Trouble-Shooting the Case Magneto. M. C. Anderson. *Aviation Maintenance & Operations*, Vol. 9, No. 1, December, 1947, pp. 26, 27, illus.

Trouble Shooting Problems: Mechanical and Lubrication. *Airports*, Vol. 13, No. 2, February, 1948, pp. 20, 21, illus.

AMC Work Guide Cuts Time for DC-4 Overhaul. Fred Hunter. *American Aviation*, Vol. 11, No. 18, February 15, 1948, p. 25.

Low Cost Airplane Cleaning. Richard W. DeMott. *Aviation Maintenance & Operations*, Vol. 9, No. 3, February, 1948, pp. 21–25, figs.

Pickling Private Planes. Robert F. Carrol. *Aviation Maintenance & Operations*, Vol. 9, No. 3, February, 1948, pp. 33, 90, 92, illus.

Precautionary measures that should be taken to prevent corrosion, deterioration, or malfunction of the air frame and power plant of the private plane subjected to outdoor winter storage.

Reclaiming Solvent Cleaners. Joseph Albin. *The Iron Age*, Vol. 161, No. 7, February 12, 1948, pp. 74, 75, illus. American Airlines' practice.

Salvage and Save by Hard Chrome Plating. Gilbert C. Close. *Aviation Service Magazine*, February, 1948, pp. 14–17, 29, illus.

Reclaiming Used Stop Nuts. *Plane Facts*, Vol. 4, No. 6, December, 1947, pp. 28, 29, table.

Rebuilding the Ercoupe Fuselage. I. Ed Packer. *Aviation Service Magazine*, February, 1948, pp. 8–11, illus.

Vertical Stabilizer Lowering Procedure (Boeing 377 Stratocruiser). *Boeing Service Guide*, No. 6, March, 1948, p. 8, diagrs.

Servicing Tips for Airliners. XVI—Hydraulic Systems. *Aviation Maintenance & Operations*, Vol. 9, No. 1, December, 1947, p. 37, table. Checklists for the Lockheed Constellation and the Douglas DC-4.

Servicing Tips For Airliners. XVIII—Oil Systems. *Aviation Maintenance & Operations*, Vol. 9, No. 3, February, 1948, p. 40. For the Lockheed Constitution and the Douglas DC-3 and DC-4.

Douglas Service, Vol. 6, No. 3, March, 1948. 20 pp., illus. Contents: DC-6 Cowl Flaps—Servicing, Maintenance, and Adjustment, DC-6. Advance Engineering Changes, DC-6. Rockwell Hardness Testing. Cabin Pressure Amplifier—Test Procedure Based on Newly Developed Tester, DC-6. Engine Oil Control—Centerspread, DC-6. Engine Oil Control—Description of Oil Flow and Operation of Cooler By-Pass Valve and Cooler Air Exit Door, DC-6. Geneva-Loc Actuators—Troubles and Corrections, DC-6. Centerspreads. Landing Gear Selection Valve—Replacement of Assist Cable and Correct Poppet Adjustment, DC-4.

Management & Finance (45)

Personal Plane Prospects. Dwane L. Wallace. *Aero Digest*, Vol. 56, No. 3, March, 1948, p. 33, illus.

16,023 Personal Planes Sold During 1947; Value $53,206,000. Alexander McSurely. *Aviation Week*, Vol. 48, No. 5, February 2, 1948, p. 31, illus.

Don't Sell Private Flying Short. Peter Altman. *Flying*, Vol. 42, No. 1, January, 1948, pp. 16–18, 78, 80, diagrs. An analysis of the personal plane market.

Materials (8)

METALS & ALLOYS

The Rupture-Test Characteristics of Heat-Resistant Sheet Alloys at 1,700° and 1,800°F. J. W. Freeman, E. E. Reynolds, and A. E. White. *U.S., N.A.C.A., Technical Note No. 1465*, February, 1948, 61 pp., illus. 3 references.

Rupture-test characteristics at 1,700° and 1,800°F. of standard chromium-nickel alloys, types 330, 310, 310S, 309 Inconel alloys, the highly alloyed Vitallium, Co-Cr-Ni, S816, S590, low-carbon N-155, and experimental alloys containing Co, Mb, W, and B, in addition to Ni and Cr. The highly alloyed materials, in most cases, had higher rupture strengths only for time periods up to about 1,000 hr. at 1,700°F. and for somewhat shorter periods of time at 1,800°F. The relative rupture strengths varied with the time period and the temperature considered. In general, Vitallium, J-838, and S590 were the strongest of the new alloys and type 310S was the best of the standard alloys. Low-carbon N-155 apparently had the best strength at time periods of 100° hours or longer.

The Use of Heat Resisting Steels in the Manufacture of Gas Turbine Blades in Germany. Reinhold Schempp. *U.S., Field Information Agency, Technical, Final Report No. 1148*, June 3, 1947. 19 pp., illus. 2 references. British Information Services, New York. $0.90.

Correspondence: High Temperature Alloys for Gas Turbines. F. M. Owner. Sir William Griffiths. *Royal Aeronautical Society, Journal*, Vol. 52, No. 446, February, 1948, pp. 138, 139, fig.

Fatigue Strength and Related Characteristics of Aircraft Joints. II—Fatigue Characteristics Of Sheet and Riveted Joints of 0.040-Inch 24S-T, and R303-T275 Aluminum Alloys. H. W. Russel, L. R. Jackson, H. J. Grover, and W. W. Beaver. *U.S., N.A.C.A., Technical Note No. 1485*, February, 1948. 97 pp., illus. 14 references.

An investigation of the fatigue properties of 0.040-in. sheet and riveted joints of the following aluminum alloys: 24S-T Alclad, 24S-T bare, 75S-T Alclad, R303-T275 clad, and R303-T275 bare. Results are given for direct-stress fatigue tests of sheet materials including unnotched specimens, specimens notched by drilled holes, and specimens with surface scratches; fatigue tests of riveted lap joints, riveted butt joints with various stiffeners, and multi-arc-welded butt joints; tests of the sheet materials and the various joints at elevated temperature (375°); and tests of cumulative fatigue damage.

Tensile, Fatigue, and Creep Properties of Forged Aluminum Alloys at Temperatures up to 800°F. L. R. Jackson, H. C. Cross, and J. M. Berry. *U.S., N.A.C.A., Technical Note No. 1469*, March, 1948. 48 pp., illus. 9 references.

Presents data on the tensile strength, fatigue strength, creep properties, and thermal expansion of forged aluminum alloys XB18S, 18S, 24S, and 32S which are pertinent to the application of these alloys in the temperature range from 70° to 800°F. Contains also a critical discussion of the data and their application to design of aircraft engines.

Thermogalvanic Corrosion. II. R. M. Buffington. *Corrosion*, Vol. 3, No. 12, December, 1947, pp. 613–631, diagr. 12 references.

The Aluminium Industry of Japan: The Raw Aluminium Industry. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./902–903.* 76 pp., tables. British Information Services, New York. $2.05.

Aluminum Alloy Castings. Floyd A. Lewis. *Materials & Methods*, Vol. 27, No. 3, March, 1948, pp. 89–104, illus. 10 references.

NONMETALLIC MATERIALS

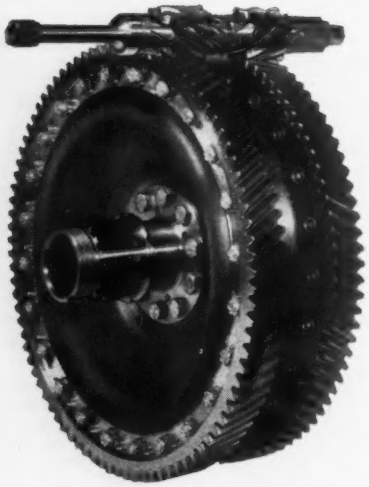
Ceramic Materials for Some Special Applications. B. C. Weber. *U.S., Air Force, Technical Report No. F-TR-1163-ND (GS-USAF-Wright Field No. 62)*, February, 1948. 5 pp., fig.

Description of Siemens refractory (Seger-Cone 26) and high refractory (Seger-Cone 36) porcelain produced for the electrical industry. Generator nozzles of silicon carbide with clay binder fired at 1,400°C. were operated at temperatures from 1,200° to 1,400°C. for periods of 1,000 to 2,000 hr. A technique was developed for the fabrication of turbine blades from a similar mixture that displayed high resistance to changes in temperature.

Investigation of German Methods of Rubber/Metal Bonding. A. A. James, G. M. Blow, and T. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 1530, Item No. 21.* 63 pp., illus. British Information Services, New York. $2.65.

"Schwingmetall"; A Process For Bonding Rubber to Steel Used Primarily For Mountings To Eliminate Vibration. S. P. Fischer. *Gt. Brit., British Intelligence Objectives Sub-Committee, Miscellaneous Report No. 40 (Technical Report No. 250-45)*, September, 1945. 10 pp., British Information Services, New York. $0.55.

Example of Experience



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SANDWICH MATERIALS

Durability of Glued Joints Between Aluminum and End-Grain Balsa. Herbert W. Eickner. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1566,* September, 1947. 14 pp., illus. 1 reference.

Results of strength tests of tension-type specimens. Aluminum cubes were bonded to end-grain balsa by three typical two-stage bonding processes and before testing were subjected to different exposure conditions for periods of from 32 to 52 weeks.

Buckling Loads of Flat Sandwich Panels in Compression; Buckling of Flat Sandwich Panels With All Edges Clamped (Cores of End-Grain Balsa or Cellular Cellulose Acetate and Faces of Aluminum or Glass Cloth Laminate). K. H. Boller. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1525-D,* September, 1947. 15 pp., illus.

Buckling Loads of Flat Sandwich Panels in Compression; Buckling of Flat Sandwich Panels With Loaded Edges Clamped and the Remaining Edges Simply Supported (Cores of End-Grain Balsa or Cellular Cellulose Acetate and Faces of Aluminum or Glass Cloth Laminate). K. H. Boller. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1525-C,* September, 1947. 16 pp., illus.

Buckling Loads of Flat Sandwich Panels in Compression; Buckling of Flat Sandwich Panels With Loaded Edges Simply Supported and the Remaining Edges Clamped (Cores of End-Grain Balsa or Cellular Cellulose Acetate and Faces of Aluminum or Glass Cloth Laminate). K. H. Boller. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1525-B,* September, 1947. 25 pp., illus. 5 references.

Developments in Aircraft Construction Using Plastic, Paper, Veneer and Thin Metal in Sandwich and Other Formations. J. H. Leigh, E. P. King, and J. E. Gordon. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 1494, Item No. 25.* 39 pp., illus. British Information Services, New York. $1.90.

Meteorology (30)

Observations on the Structure of Convection Currents; Meteorological Aspects of Some South African Gliding Flights. R. C. Rainey. *Royal Meteorological Society, Quarterly Journal,* Vol. 73, No. 317–318, July–October, 1947, pp. 437–452, diagrs. 9 references.

Leistung Einer Kumuluswolke (The Power of a Cumulus Cloud). *Schweizer Aero-Revue,* Vol. 23, No. 1, January, 1948, pp. 16, 17, diagrs.

A computation of the change in weight of one cubic meter of atmosphere in a rising air current during its ascent to 1,900 m. The weight of the atmosphere and its rate of ascent are used to calculate the potential horsepower of a cumulus cloud which is available to gliders.

M.C.A.'s Aeronautical Information Service. *The Aeroplane,* Vol. 74, No. 1918, March 12, 1948, pp. 311, 312, illus.

Arctic Conditions and World Weather. Gilbert Wolker. *Royal Meteorological Society, Quarterly Journal,* Vol. 73, No. 317–318, July–October, 1947, pp. 226–253, Discussion, pp. 253–256, diagrs., tables. 17 references.

The Structure of The Intertropical Front Over N.W. India During the S.W. Monsoon. J. S. Sawyer. *Royal Meteorological Society, Quarterly Journal,* Vol. 73, No. 317–318, July–October, 1947, pp. 346–369, diagrs. 6 references.

The Capture of Ions by Ice Particles. J. Alan Chalmers. *Royal Meteorological Society, Quarterly Journal,* Vol. 73, No. 317–318, July–October, 1947, pp. 324–334. 11 references.

The Problem of Diffusion in The Lower Atmosphere. O. G. Sutton. *Royal Meteorological Society, Quarterly Journal,* Vol. 73, No. 317–318, July–October, 1947, pp. 257–276, Discussion, pp. 276–281. 9 references.

The Estimation of Vertical Motion in the Atmosphere. R. C. Graham. *Royal Meteorological Society, Quarterly Journal,* Vol. 73, No. 317–318, July–October, 1947, pp. 407–417, diagrs., tables. 3 references.

The Significance of The Isopycnic Level. M. Doporto and W. A. Morgan. *Royal Meteorological Society, Quarterly Journal,* Vol. 73, No. 317–318, July–October, 1947, pp. 384–390, diagrs. 8 references.

A Contribution to The Problem of Development. R. C. Sutcliffe. *Royal Meteorological Society, Quarterly Journal,* Vol. 73,

No. 317–318, July–October, 1947, pp. 370–383, diagrs. 7 references.

Note on the Dynamics of Development. N. P. Sellick. *Royal Meteorological Society, Quarterly Journal*, Vol. 73, No. 317–318, July–October, 1947, pp. 453–455. 2 references.

Navigation (29)

General Methods of Navigation by Position Lines at Any Time Intervals, With Application to the Air Position Indicator. A. P. Guinand. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2189*, March, 1944. 6 pp., figs. British Information Services, New York. $0.45.

A method of finding track and ground speed from four position lines at any time intervals when the aircraft is flying with constant course and air speed. The method can be used to find the position and the wind velocity from four position lines at any time intervals when the air positions at the times of the position lines are known but various courses and air speeds have been flown between position lines. A method is also described of transferring position lines when alterations of course and air speed have been made but air positions are known.

"Polatomic" Navigation for World Air Routes. Robert I. Colin. *Air Transport*, Vol. 6, No. 3, March, 1948, pp. 28–32, diagrs.

If radio transmitters were located at the north and south geographic poles and each transmitted signals that had hemispheric coverage, it would be possible to provide pilots of long-range aircraft with direct-reading indicators that would tell the latitude and the longitude of the airplane.

Contour Sketch Fixing: Important Development in Reconnaissance Survey Work. *Flight*, Vol. 53, No. 2044, February 26, 1948, p. 234, diagrs.

An application of the Decca Navigator system which uses portable transmitters to provide signal lattice coverage. A low-flying aircraft flies over the area to be sketched and an observer records a succession of fixes at appropriate points. These fixes are later plotted as a map. The method is rapid; its accuracy is principally limited by the maneuverability of the aircraft.

Operations

COMMERCIAL (41)

Problems Facing Civil Air Operations. N. E. Rowe. *Royal Aeronautical Society, Journal*, Vol. 52, No. 446, February, 1948, pp. 87–103, Discussion, pp. 103–116, diagrs.

To provide reliable and regular service under all weather conditions requires the solution of navigational and traffic-control problems in low visibility, improvement in the approach and landing characteristics of aircraft, the development of visual landing aids, and the solution of problems of pilot fatigue. Safety can be achieved economically only by a correct appreciation of the mutual responsibilities of operators and regulatory authorities, the best use of air-traffic control, and the full development of operators' standards and methods of operation. The cost of air transportation can be reduced by designing a minimum number of types of aircraft to fulfill a wide variety of tasks.

Operational Route Analysis and Direct Flying Cost. S. T. B. Cripps. *Preprint, S.A.E. Annual Meeting*, Detroit, January 12–16, 1948. 27 pp., figs.

An exposition of a method of route analysis which gives direct answers in terms of pay load available, wind conditions, direct flying cost, total operating cost, and approximate profit potential under all operating conditions. The cruising performance of an aircraft is analyzed in terms of the maximum permissible pay load, the average wind component, and the trip time. The various cruising procedures possible for a given route are assessed on an accumulative cost basis against time in hours out. From these data and the revenue available from the pay load a route analysis is obtained which shows the most profitable cruising procedure.

Air Aids. John H. Frederick. *Distribution Age*, Vol. 47, No. 2, February, 1948, pp. 34, 66, 67, 77, illus.

A discussion of Government aids to air transportation. Since the public has been unwilling to pay a compensatory rate for the services of the air lines and since these services are demanded in the interests of the postal service, commerce, and national defense, it is the public, not the air lines, which has been subsidized.

Freight Charter Operation. *Shell Aviation News* (London), No. 115, January, 1948, pp. 7–11, illus.

Description of British air freight activities during 1947. The Handley Page Hastings and the General Aircraft Universal are evaluated as to their suitability for cargo service. The chief features of an ideal aircraft specialized for cargo transport are outlined. A comparison of the advantages of flying boats and land planes shows that land-based aircraft at present are the most practical but that there is a possible future for the flying boat in this type of service.

Spotlighting the United States–Alaska Air Cargo Potential. P. L. Breakiron and R. W. Hoecker. *Air Transportation*, Vol. 12, No. 2, February, 1948, pp. 10–16, 38, illus.

The deficiency of Alaska in food production and the high freight rates for the transporation of perishables from the United States indicate that this territory may be an ideal market for air cargo operations. Fish, pelts, and passengers offer a potential return cargo.

Flying Fish. Harry Shershow. *Distribution Age*, Vol. 47, No. 2, February, 1948, pp. 24, 25, 73, illus. The packaging, refrigeration, and distribution problems that arose with the introduction of the practice of shipping fresh salt-water fish to midwest U.S. areas by air.

Airline Aircraft in Operation and on Order as of February 15, 1948. *Air Transport*, Vol. 6, No. 3, March, 1948, p. 43, table.

Basic Doctrine and Code of Recommended Practices for Aircraft Service Operators. *Aviation Maintenance & Operations*, Vol. 9, No. 1, December, 1947, Supplement. 6 pp.

Life in the Old Gal Yet. Walter L. Flinn. *Air Transport*, Vol. 6, No. 3, March, 1948, pp. 24–27, illus. Modifications and adaptations of the DC-3 which may yield increased profits.

B.E.A.'s First Annual Report (August 1, 1946–March 31, 1947). *The Aeroplane*, Vol. 74, No. 1908, January 2, 1948, p. 5, table.

B.O.A.C. Report; Activities of the Corporation and Review of Operating Conditions with a Statement of Accounts for the Year 1946/1947. *Flight*, Vol. 53, No. 2038, January 15, 1948, pp. 55–57, illus.

Air France, A Great National Enterprise. *Air World*, Vol. 1, No. 2, February, 1948, pp. 26–30, illus.

Le Trafic Aérien Scandinave (Scandinavian Air Traffic). *Schweizer Aero-Revue*, Vol. 22, No. 12, December, 1947, pp. 519, 520. Historical.

Rail-Air Freight Service; Success of New Zealand Scheme. *Modern Transport*, Vol. 58, No. 1506, February 7, 1948, p. 9, illus.

American Outlook. N. A. Macdougall. *The Aeroplane*, Vol. 74, No. 1921, April 2, 1948, pp. 394, 395, illus.

Ordnance & Armament (22)

Zündersysteme der Fliegerabwehr (Anti-Aircraft Fuze Systems). Otto Svoboda. *Flugwehr und -Technik*, Vol. 10, No. 1, January, 1948, pp. 10–13, illus.

Parachutes*

Testing of Parachutes. E. Buehr, H. Heinrich, and W. Seibold. (*Stuttgart-Ruit, Forschungsanstalt Graf Zeppelin, ZWB/FUZ/279*, October, 1942.) *U.S., Air Force, Translation No. F-TS-3818-RE*, January, 1948. 9 pp., illus. Results of wind-tunnel tests of five parachute models to determine their stability and drag coefficients. Test setup and instrumentation and photographs of models are included.

Personal Flying (42)

Folding Wings. David H. Scott. *Air Facts*, Vol. 10, No. 12, December 1, 1947, pp. 50–54. A discussion of the increased utility and reduced operating cost that could be realized by the owner of a private airplane if personal aircraft had folding wings.

Power Plants

Power Plant Design Considerations for High Altitude. C. W. Newton. *Shell Aviation News* (London), No. 115, January, 1948, pp. 18–22, figs.

The adverse effects of atmospheric variations with altitude can be counteracted by proper design to permit satisfactory power

Douglas Uses

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LORD MULTIPLANE MOUNTINGS ON DOUGLAS DC-6 PROTECT RADIO EQUIPMENT · IMPROVE SERVICE · LIFE · PERFORMANCE

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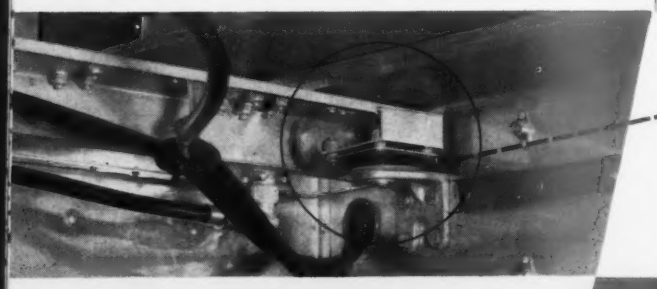
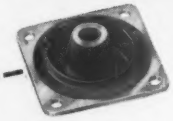
Whether you build aircraft or any other product, you can increase your sales by eliminating costly, destructive vibration. It will pay you to consult Lord . . . make us your headquarters for product improvement through Lord Vibration Control Systems.





Close-up of the Lord Multiplane Mountings used to support the radio rack shelves in the Douglas DC-6 is shown at the left. These mountings have equal rates of resiliency in all planes, insuring better vibration isolation and longer life. Send for your copy of Bulletin 106.

Douglas also uses Lord MR-36F Dynafocal Suspensions, (right) for mounting the great 2100 hp. engines of the DC-6.

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outputs to be obtained with a number of different power plants. The economy of the turbosupercharged installation makes it superior to other power plants at present available for altitudes up to 30,000 ft. For higher altitudes the reciprocating power plant must become heavier and more complex until at 40,000 ft. and above the necessary design changes become prohibitive. The turboprop engine has a satisfactory take-off power and weight ratio and between 35,000 to 40,000 ft. excels other power plants in economy. Above 40,000 ft., the turbojet engine, when fuel and oil system and temperature-shrouding problems have been solved, will probably be found to be the most satisfactory power plant.

JET & TURBINE (5)

Apparent Effect of Inlet Temperature On Adiabatic Efficiency of Centrifugal Compressors. Robert J. Anderson, William K. Ritter, and Shirley R. Parsons. *U.S., N.A.C.A., Technical Note No. 1537*, February, 1948. 18 pp., illus. 5 references.

The effects of heat transfer and Reynolds Number were also considered. The apparent variation of adiabatic efficiency with inlet temperature was practically eliminated for three compressors when the efficiency was based on diffuser-discharge temperature. Changes in Reynolds Number did not account for the variation; heat transfer from the compressor to the atmosphere seemed the most likely cause.

Enthalpy-Entropy Diagram (Combustion Gas-Kerosene) (Project No. BP-283). Heinrich Reindorf. *U.S., Air Force, Technical Report No. F-TR-1160-ND (GS-USAF-Wright Field No. 60)*, February, 1948. 13 pp., figs.

One curve for constant pressure is given for each fuel-air ratio, based on the products of combustion of one pound of air plus the corresponding amount of fuel. The diagrams consist of an enthalpy-entropy diagram, two charts of specific heat at constant pressure, and an example problem chart.

Trends in New-Type Power Plants. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 68–75, illus.

A group of 7 articles: Trends in Turbojet Design, R. P. Kroon. Turbojet Development and Production Problems, R. M. Hazen. The Prospect for Large Turboprops, Raymond W. Young. Turbine Propellers Will Be Different, George W. Brady. Pulsejet, Ramjet and Rocket Engines for Aircraft, William P. Munger. Development Facilities for Today's Engines, Wright A. Parkins. Compounding the Reciprocating Piston Engine, L. J. Fischer and W. O. Meckley.

1948 Reaction Powerplants Directory: Turbojets. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 77, 78, 80, 82, 84, 86, 87, 154, illus. Specifications and performance of American and British models: 13 turbojets, 9 turboprops, and 3 ram-jets and rockets.

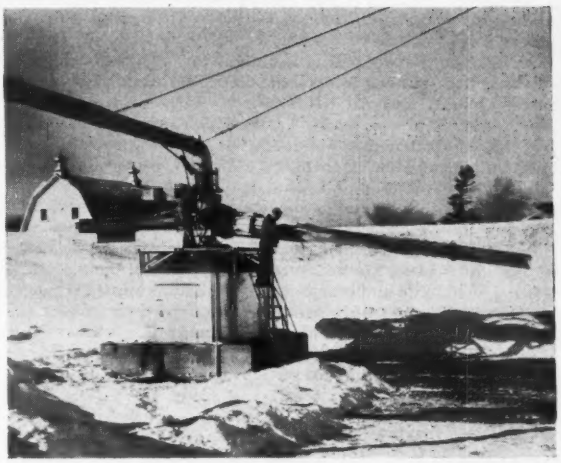
Performance Charts For the Turbojet Engine. Benjamin Pinkel and Irving M. Karp. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Paper No. 103*, 1947. 58 pp., figs., 10 references. $2.50. (Cf. AER 3/47:37.)

Stress Investigations in Gas-Turbine Disks and Blades. S. S. Manson. *Preprint, S.A.E. Annual Meeting*, Detroit, January 12–16, 1948. 15 pp., illus. 8 references.

An investigation of the temperature, temperature distribution, the total stress, and the vibrations introduced in turbine blades and discs under operating conditions. Vibratory stresses of appreciable magnitude were found to exist in the blades at turbine speeds within the cruising range. The majority of vibrations occurred in the fundamental bending mode of the blades at a frequency of approximately 1,200 cycles per sec. Vibrations in the first torsional mode occurred at about 2,000 cycles per sec. Within the cruising range of the engine, a high-frequency complex-mode vibration was noted. Combustion chambers and nozzle vanes were important sources of vibration excitation. Inner-region cooling may adversely affect the ratio of strength to stress. Improvement in the design of turbine discs could result in drastic weight reduction while still maintaining safety of operation. Rim cracking in discs with welded blades is probably attributable to plastic flow.

German Methods in Developing Turbine-Wheel Blades for the JUMO-004. Heinrich K. O. Adenstedt. *U.S., Air Force, Technical Report No. F-TR-1162-ND (GS-USAF-Wright Field No. 58)*, January, 1948. 12 pp., illus.

A brief account of the basic design, selection of materials, the problems presented by shear pins, and the fatigue and creep failure of blades. Melt and forging control, testing, tilting, and length polishing of the blades to remove transverse grinding marks are noted.



Close-up view of developmental jet power plant for helicopters and the propelling mechanism at General Electric's Flight Test Center, Schenectady, N.Y. A part of the long-range program in the development and testing of component parts for the revolutionary aircraft for the U.S. Air Force, the project is being conducted by the Thermal Power Systems Division of the General Engineering and Consulting Laboratory. The developmental jet units are located at the tip of the whirling blade.

Report on Visit to Junkers Flugzeug und Motorenwerke A.G. Dessau–Ausbildungswesen. Alan Osbourne and William P. Spofford. *Combined Intelligence Objectives Sub-Committee, Item No. 19, 5, File No. 26-23.* 10 pp. British Information Services, New York. $0.35. Description of an undesignated turbojet engine and problems encountered in its development.

Calculations of the Performance of a Compression-Ignition Engine-Compressor Turbine Combination. I—Performance of a Highly Supercharged Compression-Ignition Engine. J. C. Sanders and Alexander Mendelson. *U.S., N.A.C.A., Advance Restricted Report No. E5KO6 (Wartime Report No. E-234)*, December, 1945. 26 pp., diagrs., figs. 8 references.

Northrop-Hendy Turbodyne (XT-37). *Aero Digest*, Vol. 56, No. 2, February, 1948, p. 56, illus.

More About the Mamba Gas Turbine (Armstrong Siddeley). *The Aeroplane*, Vol. 74, No. 1914, February 13, 1948, p. 194, illus.

Mamba Unmasked; First Complete Description of Armstrong Siddeley's Small Airscrew Turbine. *Flight*, Vol. 53, No. 2047, March 18, 1948, pp. 306b–306h, cutaway drawings.

The Mamba Power Unit (Armstrong Siddeley). *The Aeroplane*, Vol. 74, No. 1919, March 19, 1948, pp. 333–336, illus., cutaway drawing.

RECIPROCATING (6)

Aircraft Power-Plant Engineering. Frank Nixon. *Air World*, Vol. 1, No. 2, February, 1948, pp. 38–39, illus.

A summary of the advantages to be gained by the design and production of self-contained power plants and an outline of the facilities and activities of the Rolls-Royce Experimental Flight Test Section at Hucknall.

Aircraft Power Plant Engineering. Frank Nixon. *Engineering*, Vol. 165, No. 4280, February 6, 1948, pp. 127–129, illus.

Investigation of Induction Swirl on Single-Cylinder Sleeve-Valve Engines. Ricardo and Company. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2192*, January, 1947. 19 pp., diagrs. 2 references. British Information Services, New York. $1.15.

An abridgement of two Ricardo reports published in 1934. The effect of swirl upon engine performance and the effect of engine and cylinder design upon the characteristics of the swirl are summarized for the Diesel and the gasoline engine. Measuring technique, nomenclature used, and an analysis of the factors affecting swirl systems are included.

A Method for Correlating the Cooling Data of Liquid-Cooled Engines and Its Application to the Allison V-3420-11 Engine. George F. Kinghorn, Albert H. Schroeder, and William K. Hag-

ginbothom. *U.S., N.A.C.A., Memorandum Report No. L5D03 (Wartime Report No. L-782)*, May, 1945. 41 pp., illus. 6 references.

A Relation Between Knock-Limited or Preignition-Limited Air-Fuel Ratio at Lean Mixtures and Fuel-Air Ratio at Rich Mixtures. John C. Evvard. *U.S., N.A.C.A., Confidential Bulletin No. E5J11 (Wartime Report No. E-208)*, November, 1945. 15 pp., figs. 6 references.

Radiators and Heat Exchangers. *The Aeroplane*, Vol. 74, No. 1917, March 5, 1948, p. 274, illus.

Description of the design and the manufacturing methods of Delaney Gallay Ltd. The primary-surface and the secondary-surface types of heat exchanger, both the straight-through and the return-flow models, are fabricated of copper. Aluminum alloy is being introduced and is expected eventually to supplant copper because of the saving in weight. Each of the return-flow heat-exchanger elements is an independent unit. These units have been integrated into a combined oil and coolant radiator.

Metallurgical Examination of Japanese Homare—II Aircraft Engine No. 11515. L. H. Grenell, J. R. Cady, and H. W. Gillett. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1468*, April 28, 1945. 56 pp., illus. British Information Services, New York. $2.50.

Bristol Brevities; Power for the M.R.E.: Hercules 630 Overhaul Periods: Free-Exit Cowl. *Flight*, Vol. 53, No. 2041, February 5, 1948, p. 141, diagrs.

A Preliminary Investigation of Exhaust-Gas Ejectors for Ground Cooling. Eugene J. Manganiello. *U.S., N.A.C.A., Advance Confidential Report (Wartime Report No. E-210)*, July, 1942. 25 pp., illus. 5 references.

Cooling Investigation of a B-24D Engine-Nacelle Installation in the NACA Full-Scale Tunnel. Robert R. Lehr, George F. Kinghorn, and Eugene R. Guryansky. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-689)*, November, 1942. 141 pp., illus. 3 references.

New Ducts Give Power Increase: By-Pass System for Takeoff Ups Constitution's Rating by 800 Hp. *Aviation Week*, Vol. 48, No. 10, March 8, 1948, p. 29, illus.

Aircraft Oil Dilution Systems. *Aviation Service Magazine*, February, 1948, pp. 18, 19, 32, diagrs.

Stratocruiser Oil System. *Boeing Service Guide*, No. 5, February, 1948, pp. 2–8, illus.

1948 Annual Directory of Aircraft Engines. *Aero Digest*, Vol. 56, No. 3, March, 1948, pp. 89–92, 94, 97, 98, illus. Descriptions and performance of 48 models.

American Aircraft Engines. *Automotive Industries*, Vol. 98, No. 5, March 15, 1948, pp. 172, 173. A table listing specifications and performance of 96 models.

British Aircraft Engines. *Automotive Industries*, Vol. 98, No. 5, March 15, 1948, p. 175. A table listing specifications and performance of 26 models.

ROCKET (4)

"Escape"-Rocket Design Research Indicates Practical Solution Near. Robert McLarren. *Aviation Week*, Vol. 48, No. 9, March 1, 1948, p. 23. 1 reference.

A description of proposed rocket-propelled radar beacon that is to be designed for flight beyond the earth's gravitational sphere. The rocket will be a five-step design and weigh over 400 tons. It will develop a take-off thrust of 3,000,000 lbs., reach a speed of 30 Mach, and carry a 10-lb. pay load.

Production (36)

Welding in the Development of Jet Propulsion Engines. H. E. Lardge. *Institute of Welding, Transactions*, Vol. 11, No. 1, February, 1948, pp. 15–24, illus.

A summary of the problems that arose from the joining techniques used in the manufacture of the W.2.B. jet engine by Power Jets, Ltd., and the Derwent I and V by Rolls-Royce, Ltd. The high-strength high-temperature materials used are not amenable to forming by spinning, pressing, or deep drawing. These facts and the need of a rapid and efficient production method led to the selection of carbon-arc and resistance welding as the methods that would minimize problems of distortion and localized stress concentration. Except for tacking purposes, seam and stitch welding were found to be most satisfactory. In the development of the air casings, however, it was necessary to substitute a mild steel for the original stainless steel because of the high stresses produced by the pulsing air flow.

Constructing Wood Rotor Blades. Paul Dolan. *American Helicopter*, Vol. 9, No. 2, January, 1948, pp. 13, 25, illus. A discussion of the selection of woods for the laminations and spars, the gluing of the laminations, assembly of the blade, and final surface finishing and balancing.

Design and Production Technique. VI—Principles Involved in Casting. J. Schroeder. *Aircraft Engineering*, Vol. 20, Nos. 227, 228, January, February, 1948, pp. 23–27; 57–60; diagrs.

General description of the process, classification of molds by type, and the influence of shrinkage and stresses on the form of the mold. 161 typical mold designs are sketched to show the effect of shape, dimensioning, location of parting faces, cores, core supports, and the importance of gates, risers, and iron chills in the cost of producing the mold, the roughcasting, the subsequent treatment and finishing, and the precision of the casting.

Big Flying-Boats Take Shape at Cowes (Saunders-Roe SR/45). *The Aeroplane*, Vol. 74, No. 1910, January 16, 1948, pp. 78, 79, illus.

Statistische Qualitätskontrolle im Flugzeugbau (Statistical Quality Control in Aircraft Construction). Ernest P. Billeter. *Flugwehr und -Technik*, Vol. 10, No. 1, January, 1948, pp. 19, 20.

A brief account of the American use of statistical theory in the standardization of aircraft production. Two examples are cited: the determination of performance standards for a design produced in a single factory and the determination of a standard for the same design manufactured in several separate installations.

Plastic Tooling Strong, Inexpensive and Easy to Produce. Lawrence Wittman. *Materials & Methods*, Vol. 27, No. 2, February, 1948, pp. 87–92, illus. 6 references.

The application, method of production, and an evaluation of molded laminate plastic tooling. Low-pressure molded laminated plastics used for checking and routing fixtures and drill jigs, in addition to being accurate, stable, durable, and permanent, are less expensive and more easily reworked than the wood or metal ordinarily used.

Spinning Magnesium. Leslie F. Hawes. *The Iron Age*, Vol. 161, No. 8, February 19, 1948, pp. 72, 73, illus.

Optical Calibrator for Bores of Small Diameter. (*Carl Zeiss, Jena, Mx/CZ/Fe 192*, 1938.) *U.S., Air Force, Translation No. F-TS-2026-RE*, February, 1948. 8 pp., diagrs.

Propellers (11)

A Comparison of Aerofoil Data for Use in Single Radius Propeller Calculations. A. B. Haines. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2188*, January, 1947. 50 pp., figs. 10 references. British Information Services, New York. $2.75.

A comparison of the mean lift-drag data obtained in three series of tests to determine how far model tests were vitiated by scale effect and how far full-scale tests were affected by the body interference inherent in the 24-ft. tunnel rig. The tests were originally conducted to derive data for use in single radius calculations of propeller performance. The comparison shows the effects on such data which are occasioned by changes in scale, blade design, and tip speed.

The Effect of Tip Modification and Thermal De-Icing Air Flow On Propeller Performance As Determined From Wind-Tunnel Tests. W. H. Gray and R. E. Davidson. *U.S., N.A.C.A., Technical Note No. 1540*, February, 1948. 47 pp., illus. 4 references.

Results of wind-tunnel tests of a method of propeller de-icing (not under icing conditions) which employed the passage of heated air through hollow blades, the flow issuing from a nozzle near the blade tip. A theoretical method resulted in a fair check with the experimentally obtained values of envelope efficiency losses which were 1 per cent through most of the test range. No additional change of efficiency was found when small amounts of heat were added to the internal flow.

Wind-Tunnel Tests of Four Curtiss Propellers Embodying Different Blade Sections. W. H. Gray. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-569)*, August, 1941. 36 pp., illus. 3 references.

Centrifugal Tests of the Chance Vought 16 Ft. 0 In. Diameter Propeller Blades Design No. CV3-377010. Earl A. Vonderheid. (Whirl Test No. 2101.) *U.S., Army Air Forces, Technical Report No. 5569*, April 18, 1947. 14 pp., illus.

Type Test of Curtiss Quickly Detachable Spinner for P-38L Type Aircraft. E. L. Haley. (Whirl Test No. 2025.) *U.S., Army Air Forces, Technical Report No. 5562,* March 12, 1947. 8 pp., illus.

Electrical Motor Test of the Aeroproducts, Model No. AD-7562-X5, Dual Rotation Propeller Equipped with Model No. H20P-156-5M5 Blades for Use on the Allison V3420-23 Engine As Installed in the XP-75 Airplane. D. F. Hild. (Whirl Test No. 1897.) *U.S., Army Air Forces, Technical Report No. 5579,* April 30, 1947. 28 pp., figs.

Electric Motor Whirl Test of the Koppers Automatic Pitch Propeller Model 543/P3-138. E. J. Thomas. (Whirl Test No. 2143.) *U.S., Army Air Forces, Technical Report No. 5571,* April 18, 1947. 15 pp., illus.

Electric Motor Whirl Test of the Curtiss No. 70 Shaft Test Club Model L-4430. E. J. Thomas. (Whirl Test No. 2158.) *U.S., Army Air Forces, Technical Report No. 5570,* April 18, 1947. 8 pp., illus.

Electric Motor Whirl Test of a Curtiss C642S-B Propeller With 732-1C2-O Design Blades. H. K. Gerritzen. (Whirl Test No. 2154.) *U.S., Army Air Forces, Technical Report No. 5567,* April 8, 1947. 10 pp., figs.

Type Test of a Modified North American P-51B Spinner, Drawing No. 104-44002, Assembled on a Hamilton Standard 11 Ft. 0 In. Diameter 24D50-J6523A-24 Propeller for Use on a V-1650-3 Engine. L. H. Corsaw. (Whirl Test No. 1847.) *U.S., Army Air Forces, Technical Report No. 5560,* March 7, 1947. 12 pp., illus.

Type Test of an 8 Ft. 3 In. Diameter Propeller Consisting of Two Laminated Natural Birch Blades, Design No. X43K21587, Assembled in a Hamilton Standard, Counterweight Type, Constant Speed Hub, Design No. 2B20-229. L. H. Corsaw. (Whirl Test No. 1778.) *U.S., Army Air Forces, Technical Report No. 5581,* May 8, 1947. 13 pp., illus.

Structural Test of a 42R61X Fixed Pitch Wood Propeller Manufactured by U. S. Propellers Inc., for Use on the DK1R-1 Target Airplane. I. R. Barr. (Whirl Test No. 2190.) *U.S., Army Air Forces, Technical Report No. 5580,* May 8, 1947. 8 pp., illus.

Endurance Test of North American Aviation Spinner No. 104-44002 for Hamilton Standard Propellers on P-51B Aircraft. E. L. Haley. (Whirl Test No. 2015.) *U.S., Army Air Forces, Technical Report No. 5586,* May 15, 1947. 3 pp., illus.

Lubricating The Translation Bearing. *The Aeroplane,* Vol. 74, No. 1918, March 12, 1948, p. 317, col. 1.

Overhauling Beechcraft Electric Propellers. *Canadian Aviation,* Vol. 21, No. 1, January, 1948, pp. 32, 36, 54, diagrs.

New Automatic Feathering System (The Convair System). *Aviation Maintenance & Operations,* Vol. 9, No. 1, December, 1948, pp. 30, 31, illus.

Airscrew Vibration Testing; D. H. Vibration Department Tackles Problems Arising from the Airscrews of the Bristol New Type 170. *Flight,* Vol. 53, No. 2043, February 19, 1948, p. 209, diagr.

1948 Annual Directory of Aircraft Propellers. *Aero Digest,* Vol. 56, No. 3, March, 1948, pp. 101–104, 106, illus. Specifications of 52 models.

Reference & Bibliography*

1948 Annual Directory of Airframe and Powerplant Manufacturers. *Aero Digest,* Vol. 56, No. 3, March, 1948, pp. 109, 110, 112, 114.

Directory of Accessories Manufacturers. *Aero Digest,* Vol. 56, No. 3, March, 1948, pp. 124–128, 130, 133–138, 140–151.

1948 Classified Index of Accessories (Airborne). *Aero Digest,* Vol. 56, No. 3, March, 1948, pp. 114, 116–118, 120, 122, 124.

Rotating Wing Aircraft (34)

Blade Pitching Moments of a Two Bladed Rotor. Ralph W. Allen. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Paper No. 100,* 1947. 18 pp., figs. 2 references. $1.00.

An investigation of the rotor blade pitching moments of a helicopter in forward flight. The blade bending characteristics are developed for a flexible blade. The analysis shows that control forces are partly the results of rotor pitching moments which increase in magnitude as the forward speed increases. Specimen curves show the frequency and amplitude of a rotor blade in bending at various forward speeds.

Flight Testing of Helicopters; A Summary of Farnborough Experiments in Test Flying the Sikorsky R-4B. I, II. Discussion. W. Stewart. *Flight,* Vol. 53, Nos. 2041, 2042, 2043, February 5, 12, 19, 1948, pp. 158, 159; 183–185; 214; illus. (Extended summary of a paper.)

I. Description of techniques developed for flight testing of helicopters. The velocities induced from the rotor and the development of the slipstream were measured by measuring velocities downstream. Smoke filaments were used to visualize the streamline, the vortex rings formed during vertical descent, and the conditions as the rotor approaches autorotation. **II.** Data are analyzed to investigate ground effect, loss of control during vertical descent, and blind-flying controllability.

Visual Rotor Aerodynamics. W. Stewart. *The Aeroplane,* Vol. 74, No. 1914, February 13, 1948, p. 188, illus. (Extract from a paper.)

These Four Types. Arthur C. Schouw. *American Helicopter,* Vol. 9, No. 2, January, 1948, pp. 10, 11, 22, 23, diagrs.

A design description and comparison of the characteristics of four types of helicopter: (1) main rotor with torque compensation tail propeller, (2) two coaxial counterrotating rotors, (3) two counterrotating rotors mounted on independent masts port and starboard or (4) fore and aft of the fuselage.

Design Trends. Hugh L. Hanson. *American Helicopter,* Vol. 9, No. 2, January, 1948, pp. 14, 24. Current trends in the design of rotors, rotor configurations, rotor blades, landing gear, and power plants.

Helicopter Emergency Landings. William E. Prindle. *Air Facts,* Vol. 11, No. 1, January 1, 1948, pp. 57–61.

How's the Helicopter Doing? Lawrence D. Bell. *Aero Digest,* Vol. 56, No. 3, March, 1948, pp. 59, 154, illus.

American Helicopter Development; Amazing Range of Rotor Configurations Tested: Progress With Jet-Driven Blades. J. C. Siltanen. *Flight,* Vol. 53, No. 2041, February 5, 1948, pp. 155–157, illus.

"New Look" in 'Copters Featured by Bristol 171. *Aircraft and Airport,* Vol. 10, No. 1, January, 1948, pp. 27, 28, 32, illus.

Low Price 'Copter Entering Field (Helicopter Engineering Research JOV-3 Tandem Helicopter). *Aviation Week,* Vol. 48, No. 3, January 19, 1948, p. 21, illus.

McDonnell Is First With Ram Jet Helicopter Design (Little Henry). *Plane Facts,* Vol. 4, No. 6, December, 1947, pp. 9, 10, illus.

Hoppi-Copter (Pentecost) in Second Test Phase. *Aviation Week,* Vol. 48, No. 10, March 8, 1948, p. 26, illus.

A Helicopter for Canada (Sznycer-Gottlieb SG Mark VI-D). *The Aeroplane,* Vol. 74, No. 1920, March 26, 1948, p. 364, illus.

United Helicopter's "Hiller 360." Franchon Devoe. *American Helicopter,* Vol. 9, No. 2, January, 1948, pp. 6, 7, illus.

Helicopter Progress at Yeovil. *The Aeroplane,* Vol. 74, No. 1917, March 5, 1948, pp. 275–278, illus., diagrs.

A detailed summary of the substitutions that will be made by Westland Ltd. in the materials and accessories to be used in the Sikorsky S-51 helicopter. These changes will be required because of the difference between British and American standards specifications.

1948 Annual Directory of Rotary Wing Aircraft. *Aero Digest,* Vol. 56, No. 3, March, 1948, pp. 60, 62, 64, illus. Specifications and performance of 20 aircraft.

U.S. Rotary Wing Aircraft. *Automotive Industries,* Vol. 98, No. 5, March 15, 1948, p. 156. A table listing specifications and performance of 15 models.

Safety & Rescue (15)

Down to Earth—But Fast. *Air Transport,* Vol. 6, No. 3, March, 1948, p. 23, illus.

A personnel evacuation chute, developed by American Airlines for use after emergency landings, eliminates the need for ramps or ladders when passengers disembark.

The Case for Shoulder Straps. F. R. Stout. *Flying,* Vol. 42, No. 1, January, 1948, pp. 33, 34, 85, illus.

Sciences, General (33)

MATHEMATICS

Assessment of Errors in Approximate Solutions of Differential Equations. W. J. Duncan. *College of Aeronautics, Cranfield, England, Report No. 13*, December, 1947. 9 pp. 6 references.

The term "Assessment" is applied to any process by which rigid bounds can be set to the error or its value can be estimated. It is shown that upper and lower bounds can be assigned whenever the Green's function of the problem is onesigned; this is true in many important problems. Another method is applicable to step by step solutions of ordinary differential equations, linear or nonlinear, and depends on use of the "index" of the process of integration. Lastly, the error in a linear problem can be estimated when an approximation to the Green's function is known.

PHYSICS

Gravity Mass and Weight. J. L. Beilschmidt. *Aeronautics*, Vol. 18, No. 2, January, 1948, p. 55. 2 references. Their relationship and the units which define them.

Stress Analysis & Structures (7)

Warping and Shear Lag in Closed Cylindrical Shells. Leon Beskin. *Journal of the Aeronautical Sciences*, Vol. 15, No. 4, April, 1948, pp. 221–231, figs. 5 references.

The state of stress in thin-walled closed cylindrical shells is determined in the neighborhood of sections with concentrated loads or sections corresponding to discontinuities of section properties. The method of successive approximations which is employed uses the conventional beam formulas as the first approximation. The second approximation, which is a first order correction of the first, generally gives sufficient accuracy for practical purposes and in many cases gives results that are extremely close to those of the correct method. This second approximation may be considered to be a type of stress distribution which produces no section warping to a greater degree of accuracy than the conventional solution. Superposition of the two solutions gives the possibility of writing arbitrary warning conditions at given sections. In the case of a section with a concentrated load it is possible to write that the mean warping due to the conventional distribution is the same on the two sides of the loaded section, thus defining the portions of the loads taken by each distribution on each side. A similar method applies to the case of a change of section properties in shear. The validity of the method, in the case of structures stiffened by frames, is limited by the fact that it is assumed that the frames are infinitely closely spaced while this spacing in fact is often of the order of, or even larger than, the characteristic length along which the nonwarping solution damps out.

Low-Speed Flutter and Its Physical Interpretation. M. A. Biot and Lee Arnold. *Journal of the Aeronautical Sciences*, Vol. 15, No. 5, April, 1948, pp. 232–236, diagrs. 1 reference.

From an examination of the basic two-dimensional flutter theory of Theodorsen it becomes apparent that to obtain a zero air-speed flutter it is necessary that the mass and elasticity of an airfoil be so distributed that a node arises at the three-quarter chord aft of the leading edge. It is further shown by an investigation of the Kutta condition that the motion of an airfoil during vortexless flutter is one of sinusoidal gliding at the three-quarter chord point. This implies that as a guide in the designing of a wing the nodal line should be as far from the three-quarter chord as practicable at all spanwise stations of the wing. A possible new approach is thus opened to the study of the flutter problem—the use of the ground vibration modes of the airplane to study the existence of low flutter speeds and to guide in designs for higher flutter speeds.

The Analysis of a Circular Ring with Propped Floor Beam. J. S. Taylor and S. S. Gill. *Journal of the Aeronautical Sciences*, Vol. 15, No. 4, April, 1948, pp. 237–242, figs., tables. 6 references.

A load distribution analysis of a circular fuselage by the strain-energy method. The circular fuselage former under consideration which has a floor cross-beam supported by four vertical props has eight redundancies. The reduction of the unknowns to five by the assumption of symmetrical floor loading and the method of tabular layout for the equations and computations greatly reduces the arithmetical work involved in the solution. The general equation for the bending moment and the partial differential coefficients with respect to the unknowns are tabulated.

An Evaluation of the Importance of Fatigue Phenomena in Aircraft; A Round-Table Discussion. C. R. Strang, L. R. Jackson, L. F. McBrearty, R. V. Rhode, and R. L. Schleicher. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Paper No. 105*, 1947. 33 pp. $1.10.

Tensor Analysis of Aircraft Structural Vibration. Charles E. Mack. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Paper No. 104*, 1947. 66 pp., figs. $2.50. (Cf. AER 4/47:28.)

The Stressing of a Rigid-Jointed Framework—Strain Gauge Analysis of the Auster Fuselage. F. Micklethwaite. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2124*, June, 1945. 19 pp., diagrs. British Information Services, New York. $1.15.

The ordinary method of stressing by taking a standard initial eccentricity on the compression members and an equivalent pin-jointed length of 80 per cent of the true lengths gives a failing load of only 61 per cent of the true failing load. Calculation of this percentage is raised to 73 per cent if the equivalent pin-jointed length of the critical strut is determined by assuming that the remote ends of the members supporting the strut are pin-jointed. By making a complete moment analysis of the plane side-frames and neglecting the cross bracing, an ultimate load of 90 per cent of the actual failing load is predicted.

Stability Theory of Compression-Stressed Sandwich Structures. Heinz Neuber. (*ZWB/LFA/Neuber/44.*) *U.S., Air Force, Translation No. F-TS-964-RE*, March, 1948. 45 pp., figs. 6 references.

A basic mathematical investigation of the stability of sandwich structures under compression. A strict solution is obtained by integration of the basic equation for the elastic stability of the structure which expresses accurately the boundary condition at the transition point between the various layers and the compressive strains in the light-weight core. The calculation is carried out for the 2-ply and the 3-ply sheet. The expressions obtained for the critical compression value and the buckling load confirm the existence of an Euler range for the structure as a whole which is

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valid for extensive buckling. This range is termed the "second Euler range" to distinguish it from the "first Euler range" in which independent buckling or denting of the skin may take place. Special diagrams in which the buckling load expressed as a dimensionless characteristic is plotted against the reciprocal wave length facilitate the determination of the optimum buckling load or skin thickness. The general method of solution which is used in this report shows that the optimum compression value with respect to buckling over the entire length can be considerably below the denting limit or in the vicinity of the second Euler range. The results also indicate that 3-ply construction is the optimum type of sandwich construction.

The General Theory of Cylindrical and Conical Tubes Under Torsion and Bending Loads. V. J. Hadji-Argyris and P. C. Dunne. *Royal Aeronautical Society, Journal*, Vol. 51, No. 443, November, 1947, pp. 884–930, figs. (Cf. AER 12/47:61.)

Alternative methods are given for determining the functions expressing the stress distribution in tubes with direct stress carrying walls, the *n*-boom tube with walls effective only in shear, the stress distributions occasioned by deflections and twist of the tube under arbitrary loading, and the warping function for arbitrary loading. The basic method for finding these functions from the appropriate cofactors of the secular equation, in which they appear directly as functions of the geometric and elastic properties of the root cross section, is applied to the four-boom tube and to the *n*-boom tube. It is also applied to the trapezoidal tube with direct stress carrying top and bottom panels. These procedures make it possible to study the effect of the functions on varying particular parameters of the cross section.

Numerical-Graphical Method of Stressing Hollow Girders. J. Lockwood Taylor. *Aircraft Engineering*, Vol. 20, No. 228, February, 1948, p. 34.

A simplified method developed from the ship-beam system and extended to axial stresses due to torsion. Successive approximations are applied to the axial strain at a series of sections of the girder at points around the circumference. The method can be applied to girders having thickness variations and stringers as well as taper in one or both views. Its accuracy is limited only by the number of steps of approximation.

Nonlinear Large-Deflection Boundary-Value Problems of Rectangular Plates. Chi-Teh Wang. *U.S., N.A.C.A., Technical Note No. 1495*, March, 1948. 113 pp., figs. 27 references.

Relaxation and successive approximation methods are used to solve von Kármán's equations as applied to initially flat, rectangular plates with large deflections under either normal pressure or combined normal pressure and side thrust. Several specific cases are analyzed. The general method developed may be applied to bending and combined bending and buckling problems with practically any boundary conditions to any required degree of accuracy, or it may be applied to solve the membrane theory of the plate which applies when the deflection is very large in comparison with the thickness of the plate.

The Influence of Aircraft Gross Weight Upon the Size and Weight of Hulls and Fuselages. L. W. Rosenthal. *Royal Aeronautical Society, Journal*, Vol. 51, No. 443, November, 1947, pp. 874–883, illus.

An analysis of the variation in beam, length, depth, and surface area of hulls and fuselages with increase in gross weight of aircraft. The curves that are obtained are projected to the gross weight range between 300,000 and 500,000 lbs. in an attempt to indicate the trend that may be expected in the design of large aircraft.

Negative Torsional Aerodynamics Damping at Supersonic Speeds. W. P. Jones. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2194*, September, 1946. 4 pp., figs. 1 reference. British Information Services, New York. $0.45.

A theoretical analysis shows that one-degree-of-freedom flutter of an airfoil can be prevented by the negative aerodynamic damping that takes place at certain axis positions, frequency parameter values, and Mach Numbers.

Summarized Proceedings of Conference on "Stress Analysis"—London, 1947. *Journal of Scientific Instruments*, Vol. 25, No. 1, January, 1948, pp. 19–23. Methods, brittle lacquers, photoelastic model materials, the frozen-stress method, and electrical resistance strain gages in static and dynamic work.

Structural Requirements and Techniques Used in Design of Japanese Aircraft. Sheldon W. Brown. *Gt. Brit., British Intelligence Objectives Sub-Commitee, Report No. B.I.O.S./J.A.P./P.R./89*, 6 pp., diagr. British Information Services, New York. $0.35. An evaluation of the limit-load, safety, and fatigue factors, the V-*n* diagram, and testing techniques in use in 1944.

20 mm. Cannon Blast Effects on Stressed-Skin Structures. Appendix III. W. T. Kirkby. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2085*, July, 1943. 58 pp., illus. 5 references. British Information Services, New York. $3.40.

An investigation to determine the best manner of reinforcing a stressed-skin structure against the blast effects from turret-mounted 20-mm. cannons. Panels 6 in. in width, of any length more than about twice the width, mounted as rigid panels, had to be of at least No. 14 standard wire gage to withstand the blast from 1,000 rounds fired at a height of 3 in. above them. Skins of sandwich construction were found to introduce considerable friction which resulted in a very rapid damping of the oscillations caused by the blast, thus reducing "working" at the edge rivet lines.

The Effect of Wing Bending Deflection on the Rolling Moment Due to Sideslip. Powell M. Lowell. *U.S., N.A.C.A., Technical Note No. 1541*, February, 1948. 18 pp., diagrs., tables. 1 reference.

A method for calculating the effect of wing flexibility on the rolling moment due to sideslip for wings of various aspect ratios and taper ratios when different shapes of the bending-deflection curve are assumed. The shape of the deflection curve is unimportant, the main factor being the amount of wing-tip deflection. An accurate and an approximate method for calculating the tip deflection are given. The effect of wing flexibility on the rolling moment due to sideslip seems to be large enough to be of appreciable importance in the design of large low-load-factor airplanes.

Calculation of the Aileron and Elevator Stick Forces and Rudder Pedal Forces for the Bell XP-83 Airplane (Project MX-511) in Spins. Ralph W. Stone, Jr., and Leslie E. Schneiter. *U.S., N.A.C.A., Memorandum Report No. L5H29 (Wartime Report No. L-575)*, September, 1945. 22 pp., illus. 3 references.

Vibration-Response Tests of A 1/5-Scale Model of The Grumman F6F Airplane in The Langley 16-Foot High-Speed Tunnel. Theodore Theodorsen and Arthur A. Regier. *U.S., N.A.C.A., Memorandum Report No. L4K18a (Wartime Report No. L-743)*, November, 1944. 24 pp., illus.

Fuselage Vertical Bending—Elevator Flutter on the Typhoon. H. A. Jahn, G. H. L. Buxton, and I. T. Minhinnick. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2121*, March, 1944. 55 pp., diagrs. 7 references. British Information Services, New York. $2.90.

Flutter calculations on the Typhoon aircraft which take into consideration elevator rotation, vertical flexure of the fuselage, pitching and vertical translation of the whole aircraft, and main wing flexure. Vertical translation and main wing flexure must be considered since resonance tests show that they affect the position of the nodes on the fuselage and consequently may influence the effectiveness of the elevator mass-balancing system. Comparison of quinary and ternary flutter calculations show that gearing of the pitching and vertical translation to the fuselage and main wing flexure on a semirigid basis gives a good approximation to flutter characteristics. Contrary to earlier calculations based on linear or parabolic flexure of the rear fuselage alone, full resonance tests were made which showed that the most important part of the fuselage bending takes place at the fuselage center section. The investigation covers the effect of main wing stiffness, modifications to the mass-balancing system including the flexibility of the control circuit, variations in the aerodynamic coefficients, change in altitude, rear fuselage damping, and elevator frictional velocity damping.

Minimising Zero-Drift in Electrical Strain Gauge Bridges. C. R. Urwin and K. H. Swainger. *Royal Aeronautical Society, Journal*, Vol. 51, No. 443, November, 1947, pp. 867–873, diagrs.

"Potential leads" were used to measure the potential drop across the gage due to the current supplied by the "current leads." This technique put strain gage switches and leads in series with the high-resistance ratio arms in a modified Wheatstone bridge. Thus the effects of switch-contact-resistance change and temperature-resistance change in the leads were minimized to any desired value. The high resistance-ratio arms allowed coarse resistance changes at the measuring bridge to measure the small resistance change caused at the gage by the strain. High potentials were applied to the bridge to minimize the effects of thermal e.m.f. Active gages and temperature compensating

(*Continued on page 97*)

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Books

Aircraft Structural Analysis. Prepared by the Engineering Staff of The Glenn L. Martin Company. Edited by G. N. Mangurian and Norman M. Johnston. New York, Prentice-Hall, Inc., 1947. 418 pp., diagrs. $8.00.

The material presented in this book was originally compiled for an intensive course given to The Glenn L. Martin Company draftsmen and engineers. It was intended to provide aircraft engineering draftsmen with sufficient knowledge of structural analysis of aircraft details to enable them to design parts for airplanes. Secondly, it was meant to refresh the memories of engineers who had studied the subject in college, but who had not been required to apply the knowledge in their daily work. These are almost literal quotations from the preface.

The presentation of the material is practical and direct. No use is made of the calculus, and even the little trignometry encountered is explained in great detail. While such a limitation of the tools of analysis might be necessary when draftsmen are taught the elements of mechanics, the reviewer would like to hope that the engineers who had studied airplane stress analysis in college will remember the rudiments of the calculus after a few years of aerodynamics, design, or other work. Otherwise he would feel that his efforts at teaching engineering have largely been wasted.

The scope of the text can be best judged from the titles of the chapters. Introduction; Loadings on an Airplane; Resolution of Forces; Shears, Bending Moments, and Torsional Moment Calculations; Analysis of Joints and Trusses; Properties of Simple Sections; Properties of Aircraft Materials; Design of Simple Sections in Tension or Compression; Design of Simple Sections in Bending and Shear; Design of Tubes in Compression, Tension, Bending, and Torsion; Structural Fastenings in Aircraft; Design of Simple Bolt Fittings; Design of Multiple Bolt Fittings with Concentric Loadings; Design of Multiple Bolt Fittings with Eccentric Loadings; Design of Sheet Splices; Structural Shape Splices; and Weight Problems in Structural Design.

Throughout the book the emphasis is definitely not on mathematical rigor. The practical point of view results in a few rather amusing inaccuracies of word usage and definition. One of the authors speaks of "analytic analysis," and another of "experimental tests." In one place it is stated that "air pressures are the forces which act upon the airplane in flight." (From this one might conclude that the inertia forces are also air pressures since they are certainly forces acting upon the airplane in flight!)

For information on I.A.S. Library Service Facilities, see page 49

However, these details should be of small importance to the graduate engineer who reads "Aircraft Structural Analysis." He will be delighted to find the wealth of practical information on structural design considerations of which he had heard little, if any, in college. As the authors put it, stress analysis is not an exact science and satisfactory results depend just as much on sound engineering assumptions as on the correctness of the analytical derivations. The airplane companies have had much experience that enables them to design strong and light structures. In some cases they may have found the correct assumptions, and in others they have possibly made two compensating errors: in any event they know that their procedure works. On the other hand, the young engineering graduate with an excellent theoretical training is often at a loss as to how to apply his theories to the complex stress problems of actual structural parts.

This reminds the reviewer of the eternal problem, how much time in a college curriculum should be taken away from the discussion of fundamental principles of mechanics and of rigorous analytical methods in order to make it available for the solution of detail problems and coaching in routine procedures. When more practical information is divulged by the stress men in the aircraft industry on usage, weight considerations, practical experience, approximate analysis and the like, such as is found in the volume written by the staff of the Glenn L. Martin Company, in a form easily understood by the average engineer, then the colleges will be able to devote all their time to the teaching of those processes of thought that cannot be easily learned elsewhere.

DR. N. J. HOFF
Polytechnic Institute of Brooklyn

Cours d'Aéronautique. Émile Allard. Paris, Dunod; Liège, Éditions Desoer, 1947. 2 vols. 325 pp., 248 figs., 6 fold. plates.

The book, though paper covered, is an example of the beautiful typography that French and Belgian publishers achieve by such simple means. Although not of much assistance to the practicing aeronautical engineer, Professor Allard's work, were it in English, would be an admirable text for an advanced or graduate course, and would provide a solid foundation for the complexities of modern aerodynamics. He achieves a clarity and conciseness of exposition that is frequently found in French, and so rarely in English. Only in Glauert, author of the famous *Aerofoil and Airscrew Theory*, would Professor Allard find a rival in exposition. The book begins rightly by reviewing two subjects that students and engineers quickly forget, the elements of vector analysis and the concepts of complex variables. Chapter II, Kinematics of Fluids, presents the classical theories of hydrodynamics, sources and sinks, the continuity equation, and the vortex laws of Thompson and Helmholtz. Chapter III follows logically with the stream function and the potential function applications of complex variables and the like. Chapter IV deals with the dynamics of fluids, and leads up to the Kutta-Joukowski theory, and Blasin's theorem. In Chapter V the lift of the cylinder with superimposed circulation forms the necessary introduction to the lifting airfoil, and is followed by the conformal transformation of cylinder with airfoil, and a fine presentation of thin wing theory and the theory of control surfaces. Chapter VI presents the Prandtl-Lanchester vortex theory of the airfoil. One regrets that Lanchester's name does *not* appear by the side of Prandtl's. In Chapter VII we find a solid presentation of viscosity, the equations of motion for viscous flow, and an adequate discussion of turbulence, the origin of circulation and turbulence resistance theory, and the boundary layer ideas. Chapter VII bears as its title "Compressibility," flow in one dimension and flow in two dimensions. Even though some fifty

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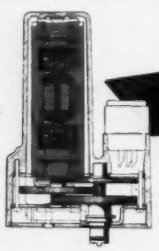

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pages are devoted to compressibility, the treatment is only an introduction. American teachers and students would miss numerical examples and problems and relationship to the airplane, but both teachers and students of aerodynamics would find this a refreshing and stimulating book, useful for review and collateral reading.

DR. ALEXANDER KLEMIN
Consulting Engineer
Greenwich, Conn.

Aircraft Engines of the World, 1948. Paul H. Wilkinson. New York 14, 225 Varick St., Paul H. Wilkinson, 1948. 320 pp., illus. $10.

The sixth edition of this annual international reference book measures up fully to the high standard of its predecessors, with new features added to increase its usefulness. The standardized data pages present the most complete record available of recent aircraft power plants, and the usual excellent full-page photographs accompany each data page. The advantages of this form of comparative presentation are becoming better known each year. The standardized data in both English decimal and metric measurements make it easy to pick out the important features of the engines.

In the Reciprocating Engines section, complete specifications are given for 106 basic engines manufactured in 12 countries, including Argentina, of which specifications 24 are new and many contain important revisions. Particulars of many other models are given, including the new 2,000-hp. AM-42 engine manufactured in the U.S.S.R. The usual tabulation of high-powered engines, completely revised, now gives the grade of fuel used and any provision for water injection for each engine. New reciprocating engines include the Continental C-90 and C-145, Franklin 0-425 and 6ALV-335 (helicopter), Lycoming R-680-10, Pratt & Whitney Twin Wasp R-2180, Wright Cyclone R-3350 18CA, Bristol Hercules 763 and Centaurus 663, Rolls-Royce Griffon 57 and Eagle 22, Instituto Aerotecnico El Gaucho and El Indio, Mathis 4G-60 and 8G-20, Alfa Romeo 121, and Svenska Flygmotor Trollet.

The Jet Engines and Gas Turbines section, always of great importance, has been increased to 74 pages and now contains complete specifications of 31 recent engines, of which 16 are new. The introduction of this section is comprehensive and includes items of interest such as progress and trends, engines exported or licensed to other countries, developments in the U.S.S.R., world's records won with jets, and new jet engine equipment. A notable inclusion is a set of specifications and photographs of jet engines of German origin which are now in production in the U.S.S.R. The tabulations of 31 turbojets and 15 turboprops are unusually complete and permit comparison of these power plants with the reciprocating engines. New jet engines include the Aerojet 12 AS-

250, Allison J-33 (Model 400), Boeing 500 and 502, General Electric T-31 (TG-100B), Armstrong Siddeley Mamba, Bristol Theseus 11, Fedden Cotswold, Metropolitan-Vickers Beryl, Napier Naiad, A. V. Roe Canada Chinook, Heinkel-Hirth HeS 011 (modified), U.S.S.R. M-003E, M-003R, M-004, and M-018. The new tables of fuels and lubricants for reciprocating engines and jet engines are a timely addition and should prove useful since they give the latest specifications, properties, and weights of both American and British products in comprehensive form for the first time. For an accurate, up-to-date, and well indexed reference book on jet and reciprocating engines, this book is highly recommended.

MAURICE H. SMITH
Curator Librarian, I.A.S.

Book Notes

AERODYNAMICS

INTERNAL FLOW

Centrifugal and Axial Flow Pumps; Theory, Design, and Application. A. J. Stepanoff. New York, John Wiley & Sons, Inc., 1948. 428 pp., diagrs. $7.50. The rapid advances in the design and applications of centrifugal and axial flow pumps have removed many limitations of pressure, capacity, temperature, and speed of operation and have made the appearance of this book timely. The use of a simple diagram combining the essential design and performance elements of centrifugal, mixed flow, and axial flow pumps makes possible a theoretical treatment based on a single pattern of flow, using identical theoretical reasoning and similar procedures of impeller layout for all these types of pump. Bibliographical references follow each chapter. For data not duplicated in this book, the author refers to the *Standards of the Hydraulic Institute*. The author is with the Ingersoll-Rand Company.

PERFORMANCE

Performance and Longitudinal Stability of Jet Propelled Aircraft, with Special Consideration of Flying Airplane Models. P. Bielkowicz. London E.C. 1 (52, Halton House, 20/30 Holborn), Alma Book Co., Ltd., 1947. 79 pp., figs. 8s. Methods of computation for longitudinal stability, characteristics of the wing, location of the neutral point, and setting of the tail plane are presented, with a final chapter on performance and flight conditions. An alternate and more exact method of computing induced drag, aerodynamic center location, and the slope of the lift curve of a tapered wing is given in an appendix. The reader unfamiliar with calculus can use the obtained formulas in their final shape, without reference to the complete argument. A bibliography of eleven items is included.

AIR POWER

Statistical Study of Registered Civil Aircraft as of November 1, 1947. Washington, U.S. Civil Aeronautics Administration, Office of Aviation Information, 1948. 41 pp. Registered aircraft are listed by manufacturer, with specification number, model, engine and horsepower, year of manufacture, and the number of each model registered. By a system of symbols, such designations as number of places, landplane, flying boat, amphibian, helicopter, and open or closed cabin, are given in a separate column. Major manufacturers form the first part of the book, which is followed by a miscellaneous part listing 631 aircraft mostly experimental, restricted, or unspecified. Gliders and lighter-than-air are listed in Part III.

AVIATION MEDICINE

Psychology and Military Proficiency. Charles W. Bray. Princeton, N.J., Princeton University Press, 1948. 242 pp., illus., diagrs. $3.50. Research on the classification of military and naval personnel during World War II is described, which contributed to the selection and training of men in such fields as radio code and radar operation, voice communication in the Army Air Forces, stereoscopic height finder and range finder operation, antiaircraft artillery, and B-29 gunnery. Experimental methods and results are included in the discussion. This is the official history of the Applied Psychology Panel of the National Defense Research Committee, of which Professor Bray was first technical aide and later chief. The book, while not intended for laymen, can be readily understood by the nonpsychologist. Footnote references are included.

The Use of Aircraft in the Control of Mosquitoes. (A.M.C.A. Bulletin No. 1.) New Brunswick, N.J., American Mosquito Control Association, March, 1948. 67 pp., illus., diagrs. $1.00. A complete survey of activities in this field, including types of aircraft and equipment, materials, and operational and safety procedures. Over one-third of the book consists of 16 technical appendixes on types of dispersal equipment, specifications for types of DDT and solvents for them, fuel oil insecticides, and xylene, sample record forms, an analysis of expenditures on an actual operation, and directory information. The various data are supported by 45 photographs and drawings.

ELECTRONICS

Radar Beacons. Edited by Arthur Roberts. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 3.) New York, McGraw-Hill Book Co., 1947. 489 pp., illus., diagrs. $6.00. The purpose of this book is to give a comprehensive survey of the present state of knowledge on radar beacons. It is the first book to be published devoted entirely to this subject. Part I deals with the uses of radar beacons; the requirements of systems using beacons, including range, propagation and coverage; frequency, and traffic and engineering considerations; and coding and communication. Part 2, on beacon design, takes up nearly half of the book and includes radio-frequency components, beacon receivers, interrogation coding, response coders, beacons as pulse communication systems, modulators, magnetrons, triode transmitters, power supplies and performance testing, and beacon synthesis. Part 3 takes up the design of beacon interrogators and gives examples of typical beacon systems, such as the airborne-radar-ground beacon, ground-radar-airborne-beacon, and Shoran systems. The final part takes up the installation, operation, and maintenance of ground, airborne, ship, and portable and mobile beacons. Footnote references and a glossary are included.

Loran, Long Range Navigation. J. A. Pierce, A. A. McKenzie, R. H. Woodward. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 4.) New York, McGraw-Hill Book Co., 1948. 476 pp., diagrs. $6.00. The purpose of this volume is to describe the principles and equipment of the Loran system as they existed at the end of the war, and to offer suggestions for their adaptation and improvement for peacetime air-line service. The first part reviews the history of Loran and discusses the principles of operation, wave propagation, and methods of computation of Loran tables and charts. The second part deals with Loran equipment, including timers, switching equipment, transmitters, antenna systems, and receiver indicators. Appendixes are included on the Loran program in the Hydrographic Office, a list of Loran ground stations, demonstrations, concerning the geometry of Loran lines, and determination of errors in the positions of Loran transmitting stations. A bibliography of about 170 references, classified by types of publications and subjects, is included.

Microwave Receivers. Edited by S. N. Van Voorhis. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 23.) New York, McGraw-Hill Book Co., 1948. 618 pp., diagrs. $8.00. Detailed analytical descriptions are given of the receivers and circuits developed from radar techniques. The presentation has been kept as fundamental as possible, in order that these circuits may be applied in other fields requiring high sensitivity and excellent transient behavior. Among the topics dealt with in the first half of the book are automatic frequency control systems and circuits, intermediate frequency circuits and amplifiers, very high frequency amplifiers, mixers, and oscillators, video amplifiers, second detectors, gain and control circuits, mechanical construction of receivers, and radio-frequency and intermediate-frequency test equipment. The second half deals with an airborne receiver incorporating anticlutter circuits, a receiver for an automatic-tracking radar, and moving target indicator, superheterodyne, crystal-video, and superregenerative receivers.

Klystrons and Microwave Triodes. Donald R. Hamilton, Julian K. Knipp, and J. B. Horner Kuper. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 7.) New York, McGraw-Hill Book Co., 1948. 533 pp., diagrs. $7.50. The aim of this technical and theoretical study is to cover the basic principles of klystrons and planar grid tubes operating as oscillators and amplifiers, and to provide fundamental material for the microwave vacuum tube designer and user. Descriptive material has been largely excluded in the interest of a complete and rigorous treatment. While the emphasis is on the frequency region above 3,000 Mc. per sec., the principles apply to lower frequencies. Following an introductory part on tube types and functions and basic electronic phenomena common to all types of tubes, the second part takes up the characteristics of planar space-charge tubes. The greater part of the book, about three-fifths, deals with the various forms of klystrons.

Microwave Duplexers. Edited by Louis D. Smullin and Carol G. Montgomery. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 14.) New York, McGraw-Hill Book Co., 1948. 437 pp., illus., diagrs. $6.50. The aim of this book is to present the theory and the practical aspects of the design of duplexing circuits for use in microwave radar equipment, and of the gas-filled transmit-receive (TR) tubes and anti-transmit-receive (ATR) tubes used in these duplexers. The first four chapters deal with the properties of TR and ATR tubes operating at a power level less than that required to initiate a discharge in the tube. Following chapters deal with the characteristics of high-frequency gas discharges in these tubes, high power characteristics of the tubes, branched duplexing circuits, branched and balanced duplexers, and specialized measurement techniques.

Crystal Rectifiers. Henry C. Torrey and Charles A. Whitmer. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 15.) New York, McGraw-Hill Book Co., 1948. 443 pp., illus., diagrs. $6.00. The purpose of this book is to present the knowledge on crystal rectifiers accumulated during World War II. Because of the need for compact and stable microwave converters in radar sets, a large part of the development work was on crystal rectifiers for this application, and about half of the book deals with the theory and properties of the crystal converter. Low-level detection, high-inverse-volt-

age rectifiers and welded-contact germanium crystals are other applications discussed in the section on special types. Manufacturing techniques, methods of measurement, and production and routine testing are discussed in appropriate chapters. Footnote references, largely to original reports prepared during the war, are included, although much of the material cited is not widely available as yet.

National Electronics Conference, Chicago, October 3-5, 1946. Proceedings. Evanston, Ill., c/o Northwestern University, Electrical Engineering Department, 1947. 739 pp., illus., diagrs. $3.50. About 60 full papers are included on the theory and applications of electronics in research, communications, and industry.

Partial contents: Stratovision—Aircraft Requirements, by W. K. Ebel; Television Equipment for Guided Missiles, by Charles F. Marshall and Leonhard Katz; Improvements in 75-Megacycle Aircraft Marker Systems, by B. Montgomery; Automatic Radio Flight Control, by F. L. Moseley and C. B. Watts; Navaglobe—Long-Range Radio Navigation System, by P. R. Adams and R. I. Colin; Teleran—Air Navigation and Traffic Control by Means of Television and Radar, by D. H. Ewing and R. W. K. Smith.

INSTRUMENTS

Theory of Servomechanisms. Edited by Hubert M. James, Nathaniel B. Nichols, and Ralph S. Phillips. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 25.) New York, McGraw-Hill Book Co., 1947. 375 pp., diagrs. $5.00. The first part deals with servomechanisms in which the error data are supplied in an uninterrupted flow. An introduction is given to the mathematical concepts and techniques fundamental to the theory of servomechanisms, including ways in which the behavior of linear filters in general and servomechanisms in particular can be described and the relations between the various modes of description. This part concludes with chapters on Servo Elements and General Design Principles of Servomechanisms. The second part deals with filters and servo systems in which the error data are supplied intermittently. The mathematical introduction, on Statistical Properties of Time-Variable Data, is followed by development of the Runs-Error Criterion in Servomechanism Design, in which the error transfer function is weighted according to its probability of occurrence. In the final chapter, on Applications of the New Design Method, an approach is made to a program of optimal designs for general types of input signals and noise, to avoid detailed calculations for each application. The book ends with an example of the use of runs-error criterion in determining the best time constant for an aided-tracking system with a hand-wheel input. Bibliographical footnotes are included throughout.

United States Navy Synchros, Description and Operation. (Ordnance Pamphlet No. 1303; a joint U.S. Bureau of Ordnance and Bureau of Ships publication, 15 Dec. 1944). Prepared by RCA Service Co., Inc. Washington, U.S. Govt. Printing Office, 1948. 165 pp., diagrs. $0.50. The principles, installation, and maintenance of standard Navy synchro equipment, known also as Selsyn (General Electric Company); Teletorque (Kollsman Instrument Division of the Square D Company) and Autosyn (Bendix Aviation Company).

The Science of Clocks and Watches. 2nd Ed. A. L. Rawlings. New York, Pitman Publishing Corp., 1948. 303 pp., diagrs. $5.00. In this new edition of the standard modern work on scientific horology, first published in 1944, new material has been added especially on the poising of watch balances, the effect of moving of the center of gravity of the hairspring, quartz crystal clocks, automatic winding mechanisms, American marine chronometers, improved apparatus for making star observations in fundamental time determination, and the Shortt "free pendulum clock." The author is a special research engineer with the Sperry Gyroscope Company. A bibliography of about 40 items is included.

MATERIALS

The Fracture of Metals. Maxwell Gensamer, Edward Saibel, John T. Ransom, and Robert E. Lowrie. New York, American Welding Society, 1947. 84 pp. $1.00. This critical review of the state of knowledge existing on the fracture of metals was authorized by the U.S. Navy Bureau of Ships as a first step for a program of study of this field. It is based on a search of the literature and direct interviews with authorities. While a satisfactory theory of design exists for failure defined as a certain amount of plastic flow, there is no satisfactory theory where the safe range is limited by fracture rather than plastic flow. The crack theory, based on the energy required to propagate a crack through the metal, and a second theory, based on an analogy between rupture and melting, have not been extended to explain the effect of the variables on the fracture strength, but together may form the basis of a new theory. A recommended research program and a bibliography of 293 items are included.

The Corrosion Handbook, Edited by Herbert H. Uhlig, and Sponsored by The Electrochemical Society, Inc. New York, John Wiley & Sons, Inc., 1948. 1188 pp., illus., diagrs. $12. Previous to publication of this handbook, general sources for corrosion data were limited to textbooks more than ten years old and a German compilation almost as old. The present handbook covers the entire field of corrosion, bringing together information scattered in the scientific and engineering literature or previously unpublished. It contains over 140 chapters by more than 100

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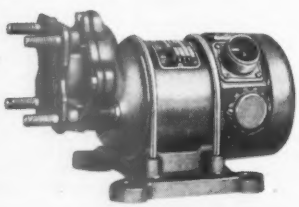

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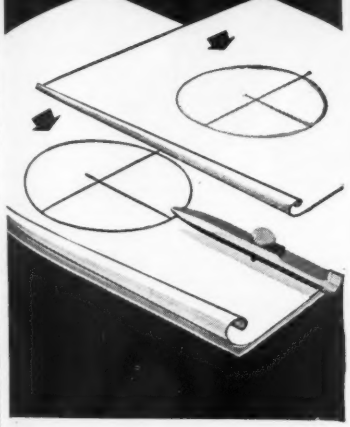

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authorities. The first four chapters deal with corrosion theory. Corrosion in liquid media, the atmosphere, and gases is next taken up in 50 chapters on various metals, nonmetallic materials, and semimetals. The third section, on special topics, contains 21 chapters, including corrosion by sea water, soils, steam, lubricants, and the effect of mechanical factors on corrosion. There are 19 chapters on high temperature corrosion, 20 on corrosion protection, and 24 on corrosion testing. A glossary of about 120 corrosion terms is included, and 37 pages of general tables. The index is detailed, covering 25 pages. There are about 1,500 references in footnotes and at the ends of most chapters.

Surface Finishing of Aluminium and Its Alloys. (Information Bulletin No. 13.) London, The Aluminium Development Association, 1947. 43 pp. 1*s*. Cleaning and degreasing, mechanical and chemical processes, electroplating, and paint finishes are discussed. A bibliography of 25 items and a list of British specifications are included. Anodic oxidation is taken up in a separate bulletin, No. 14, of this series.

Powder Metallurgy, its Physics and Production. Paul Schwarzkopf, in Collaboration with C. G. Goetzel, George Stern, Robert Steinitz, and Werver Leszynski. New York, The Macmillan Co., 1947. 379 pp., illus., diagrs. $8.00. The first 114 pages deal with the processing of metal powders, with emphasis on the interrelationship of the characteristics of metal powders and the processes of compacting, sintering, and treatment subsequent to sintering. Production problems are also included in the review of specific powder metallurgic products which takes up the next 140 pages. Applications of products are included throughout. The theoretical principles of powder metallurgy, beginning with the work of Sauerwald in 1922, are discussed in a third section. There is a brief discussion of future developments, followed by a 48-page supplement on processing, products, and theory based on data published after the manuscript was completed. There are 591 references in four bibliographies. An author index is supplied and a subject index to the text. One of the conclusions is that high-temperature alloys for gas turbines, jet propulsion, or atomic power plants will have to be produced by powder metallurgy. The author has been in the field for over 30 years, and the book can be recommended for its thorough coverage of both practice and theory.

Modern Plywood. 2nd Ed. Thomas D. Perry. New York, Pitman Publishing Corp., 1948. 458 pp., diagrs. $6.00. In this revised and enlarged edition of an excellent book first published in 1942, the text has been extensively revised. New material has been added throughout, particularly in the chapters on adhesives, plywood manufacturing, and plywood in industry. The glossary includes about 700 terms, an increase of about 200. References are given at the ends of chapters, rather than in one classified bibliography, as in the first edition, and references published before 1938 are usually not included in the second edition.

NAVIGATION

Practical Air Navigation. 6th Ed. (Commercial Edition). Thoburn C. Lyon. Silver Spring (8814 Reading Road), Maryland, The Author, 1948. 356 pp., illus., diagrs., fold. chart. $2.50. Chart alone, $0.50. First published in 1935 by the U.S. Coast and Geodetic Survey, this book was last completely revised in 1944 and published in 1945 as *Civil Aeronautics Bulletin No. 24* with some additional revisions. The author has revised the text throughout for this commercial edition, particularly the chapters on chart reading, instruments, and radio navigation, and has added new chapters on light-plane navigation, electronic navigation, pressure pattern flight, and long-distance navigation. Many illustrations have been redrawn and new ones have been added, and the accompanying study chart has been revised to provide for comparison of treatment of the same area on different types of charts and different scales.

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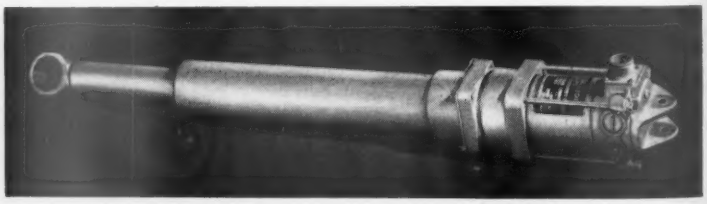

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Student Branches

(*Continued from page 13*)

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Election of officers was held with the following results: Chairman, H. Studley; Vice-Chairman, R. B. McIntyre; and Secretary-Treasurer, Homer D. Ludwig, Jr.

University of Detroit

At the April 1 meeting, eliminations in the local research paper contest were held. Russell J. Cornair, Chairman, presided.

John Basonese presented his paper, "Chamber of Commerce of Light Aircraft Manufacturers," and Arthur W. Hindenlang spoke on the subject of "Air Freight." Both were creditable papers; however, the judges, Professors Godfrey and Markle, decided in favor of Mr. Hindenlang's paper. Besides winning a Marks Handbook, Hindenlang represented the university in the Tri-University Meeting held at the University of Michigan April 12.

University of Florida

At the April 6 meeting, plans were announced for the Engineers' Field Day and Sigma Tau Ball by H. F. Weisenburger. Professor Thompson also reported that the Aeronautical Engineering Department was progressing in moving into the new hangar.

The meeting then was addressed by Prof. William T. Tiffin, Mechanical Engineering Department, who spoke on "Welding in the Aircraft Industry."

University of Illinois

Four films were shown at the April 7 meeting, Edward J. Brisick, Chairman, presiding. Attendance was 95.

After the showing of the films, which included *Engineering Staff Report No. 5; Jet Rocket Assist for the P-51; Glider Tests at Wilmington*, and *Tests of the XP-67*, all obtained from Wright Field, a proposal from the Notre Dame Branch was discussed. The proposal, revival of the regional meetings held before the war, was received with enthusiasm.

An attempt was made to shorten the meetings by eliminating business matters that could be presented in the form of a bulletin, in order to accommodate those members who have at their disposal only a short period of time for the evening meetings. The bulletins, presenting acknowledgments and miscellaneous items, will be distributed at all meetings.

University of Michigan

On April 12, the Student Branch was host to the senior members of the Detroit Section, the University of Detroit Branch, and the Wayne University Branch at the first annual Tri-University meeting. Wilbur C. Nelson, Chairman of the Detroit Section, presided.

Purpose of the meeting was to stimulate interbranch activity and to promote individual student participation through the presentation of technical papers. Each Branch was represented by one student and paper. Attendance was 200.

Professor Nelson acted as adviser on most of the planning.

Among the notable guests were: Dr. Ivan C. Crawford, Dean of the College of Engineering, University of Michigan; Prof. Kenneth Smith, Head of the Aeronautical Engineering Department, University of Detroit; Prof. Arthur A. Locke, Head of the Aeronautical Engineering Department, Wayne University; and Prof. Emerson W. Conlon, Head of the Aeronautical Engineering Department, Michigan.

Judges of the technical papers were Robert Insley, Continental Motors Corporation; B. J. Simons, Stinson Aircraft Division, Consolidated Vultee Aircraft Corporation; and Kenneth R. Herman of Vickers, Inc.

Following a trip through the supersonic wind tunnel at Willow Run, a banquet was held in the evening at which the guest speaker, Amron H. Katz, of Wright Field, spoke on "Air Force Photography."

Mr. Insley, the toastmaster, then introduced the student speakers. First was William A. Hindenlang, University of Detroit, who presented his paper, "Air Freight." He was followed by Howard Berger, University of Michigan, who spoke on "Practical Aspects of the Laminar Flow Wing." Third speaker was Arthur R. Pearce, Wayne University, who gave "Altitude Effects on Long-Range Performance of Aircraft."

The judges chose Mr. Hindenlang the winner. He received a plaque to be kept at the University of Detroit for the next year, in addition to an individual trophy for himself.

University of Notre Dame

Following a brief business meeting April 8, J. J. Clarkson, Assistant Manager to the Engineer, Fractional Horsepower Motor Engineering Division, General Electric Company, spoke on "History and Background of Jet Propulsion."

According to Mr. Clarkson, the first successful application of jet propulsion was made in 1918 by Samuel A. Moss in the form of a supercharger. Moss utilized a Frenchman's idea of using exhaust gases to compress air in an engine. The supercharger was sold to the Air Forces after a series of tests in which the power of a 230-hp. Liberty engine was increased by 120 hp.

During the '20's and '30's little was done in research on superchargers and jet propulsion, Mr. Clarkson said. Then Group Captain Whittle of the Royal Air Force developed the idea of using exhaust gases for additional thrust. The first jet engine Whittle built was sent to the United States to be studied by G-E engineers, from which was developed the engine used in the Bell P-59.

Clarkson told of further models developed by General Electric and mentioned there still are a great number of problems to be solved in the jet engine.

The Pennsylvania State College

Two films were shown at the April 7 meeting: *High Altitude Flight and Aerobatics*, and *Jet Propulsion*. Chairman William W. Sunday presided.

At the April 14 meeting, election of officers for next year was held. The new executive committee is composed of Donald A. Liebel, Chairman; Joseph T. Minarovich, Vice-Chairman; John T. Kutney, Secretary; and Charles H. Seaton, Treasurer.

Purdue University

A special meeting was held April 13 for T. P. Peppler, Chief Flight Test Engineer, McDonnell Aircraft Company, who came to interview seniors of the Aeronautical Engineering School. Chairman George Campbell presided with 250 persons attending the meeting.

Peppler explained the operations underway at McDonnell and briefed the students about the company.

Two films by McDonnell Aircraft were shown: one on McDonnell's Little Henry ram-jet helicopter, the other on the Banshee, Navy jet fighter.

Spartan College

Election of a Chairman and Corresponding Secretary was the main business of the April 1 meeting. To

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replace Ernest J. Merz, who was graduated, Gene Hess was elected Chairman, and Patrick J. Mango was elected to succeed Franklin T. Nelson as Corresponding Secretary.

Stanford University

A summary of the President's Air Policy Commission Report, *Survival in the Air Age*, was given at the April 14 meeting by K. Lindell, student member. W. C. Tripp followed with a discussion of the report.

Syracuse University

Chairman Bramhall opened the April 10 meeting, requesting all present members to cooperate in a drive to increase membership in the Branch.

Richard Klock, student member, led a group discussion of recent design errors that lead to major crashes, fatal and nonfatal. Professor Barzelay, the Honorary Chairman, noted reasons why the design errors occurred and offered some points on the "battle" between the designers and the manufacturers.

Tri-State College

A letter from the Notre Dame Student Branch, concerning the revival of regional meetings, was discussed at the March 31 meeting, Chairman David J. Russell presiding.

Tri-State College Branch will furnish full support to, and active participation in, the regional meetings proposed by Notre Dame.

Vice-Chairman R. A. Laurito reported that the barrel-type wing project will be wind-tunnel-tested soon, and Harry L. Roland that the V-tail project also will be tested by Robert Smith, Boyd Smith, and Charles Genetti after fittings have been added to the assembly. Research and construction of a helicopter model is under way by W. Austin, R. Boose, D. Kintis, and J. Remsch.

Six Committees were appointed by the Chairman as follows: Publicity: D. M. Gurney, F. C. Townes; Propeller: R. A. Laurito, J. H. O'Hare; Program: W. W. Johnson, J. F. Reinsch, Jr., A. I. Welch; Annual Field Trip: R. F. Boose, R. W. Isbell; Membership: R. S. Peterson, R. Smith; Rocket Society Representative: D. J. Russell.

Virginia Polytechnic Institute

Preceded by the film, *Messerschmitt 110E*, an election of officers took place with the following results: Chairman, H. C. McClanahan; Vice-Chairman, R. F. Wallace, Jr.; Secretary, G. L. Cahen; and Treasurer, W. B. Warwick.

At the April 19 meeting, E. F. Schoch, Engineering Test Pilot of McDonnell Aircraft gave a brief talk on the company after the showing of "Little Henry," the small jet helicopter developed by McDonnell.

News of Members

A. S. Amorim, formerly an Engineer with the Brazilian Air Force, is Assistant Director, Aeronautical Institute of Technology.

Karl M. Anderson is Engineering Designer "B" with North American Aviation, Inc. He had been with Douglas in the same capacity.

Speas Anderson, Navy veteran who had been Development Engineer, Cornell Research Laboratory, is now at Bell Aircraft Corporation as Mechanical Research Engineer.

Charles D. Auld is Aeronautical Engineer, Aerodynamics Division, David Taylor Model Basin, Navy Department.

Edgar O. Baumgarten, former Sales Engineer at Martin Iron Works, is Assistant Project Engineer, Ryan Aeronautical Company.

Emric William Bergere is with Consolidated Vultee Aircraft Corporation as a Designer. He was with Aviation Service Company as Chief Engineer.

Albert F. Broz has been named Vice-President, Engineering, of J. R. Robbins & Associates. He previously was Chief Engineer, Hydraulics, Inc.

Douglas W. Burton, former student at Cornell University, is now with Carbide & Carbon Chemical Company as Technical Engineer.

John F. Ceccarelli, A.A.F. veteran, is with Electrol, Inc., as Structures Engineer. Before going into military service he had been Design Engineer with The Glenn L. Martin Company.

Russell H. Cole, formerly with Power Plant Division, Menasco Manufacturing Company as Development Engineer, is Design Engineer, Hydro-Aire Inc.

Richard T. Crane is a Director of The Flight Safety Foundation. He formerly was President of Airline Feeder System.

John H. Cunningham has joined the staff of General Electric Company as Engineer, Rotating Engineering Pool. He had been with McDonnell Aircraft as Senior Detailer B Layout.

Douglas T. Egbert is Head, Structural Dynamics Subsection, Bureau of Aeronautics, U.S. Navy Department. He resigned as Aeronautical Engineer, North American Aviation, Inc.

Thomas M. Evans, former Consultant, Wickman Corporation and X-Ray Inc., is now Sales Engineer, Detroit Testing Laboratory.

Edward W. Gallagher resigned as Project Engineer, Wright Field, to become Engineer, United Aircraft Corporation.

Glenn E. Graham is Engineer with United Air Lines, Inc. He had been Executive Engineer, Jeppesen & Company.

Robert E. Gwinn, former Ensign, U.S. Naval Aviation Engineering, now is Guided Missile Flight Test Engineer, McDonnell Aircraft Corporation.

Marvin I. Haar is Project Engineer at the Experimental Towing Tank, Stevens Institute of Technology. He formerly was N.A.C.A. Mechanical Engineer at Langley Memorial Aeronautical Laboratory.

Stuart H. Hahn has been named Chief Mechanical Engineer, Dalmo-Victor Company. He resigned as Project Engineer, AiResearch Manufacturing Company of Arizona.

William J. Henkels accepted a position at David Taylor Model Basin following his resignation as Detail Designer at McDonnell Aircraft Corporation.

Henry Hochfeld, formerly Chief Engineer, Associated Foundries & Manufacturers, Inc., now is owner of Techna Industrial and Engineering Company.

Ben Kaufman, former Engineer with Patek Cameras, Inc., is Sales Manager, Helicopter Engineering Research Corporation.

Victor M. Kibardin is with the National Bureau of Standards. He had been Supervisor in the Electronic Trainer Department, Curtiss-Wright Propeller Division.

Spero Anthony Kondoleon has been named Aerodynamics Engineer, Pilotless Plane Division, Fairchild Engine & Airplane Corporation.

William F. Leineweber, Jr., is Chief Engineer, W. D. Dodenhoff Company. He had been Development Engineer with The Weatherhead Company.

Berthold A. Lindner, former Project Engineer, Eastern Aircraft Division, General Motors, now is Manager, Washington Engineering Branch, Fairchild Aircraft Division, Fairchild Engine & Airplane Corporation.

Joseph H. Lipow is the owner of J. H. Lipow Engineering Company. He had been with Hughes Aircraft as Research Engineer.

Harry Louis is Superintendent of Engineering, Canadian Pacific Air Lines Ltd., following his promotion from Chief Aeronautical Engineer in the same firm.

Robert M. Love, President, All-American Aviation, was made Honorary Commander of the British Empire—he was Deputy Chief of Staff, Air Transport Command, during the war.

Richard J. MacDonnell, former U.S. Navy Ensign, is with Chance Vought Aircraft Division of United Aircraft Corporation.

Fred J. Mack, Jr., is Design Draftsman, Henry Dreyfuss (Industrial Designer). Prior to taking a course at Pratt Institute, he had been with The Glenn L. Martin Company as Assistant Group Engineer.

Edward F. Martin, Jr., who has been with Lockheed Aircraft Corporation as Structural Salvage Engineer, is a student at University of California.

Leopold R. Michel, former Aeronautical Engineer, Douglas Aircraft, is Senior Engineer, Pilotless Plane Division, Fairchild Engine & Airplane Corporation.

Robert A. Miller resigned as Draftsman with The Glenn L. Martin Company to become Aerodynamicist, Pilotless Plane Division, Fairchild Engine & Airplane Corporation.

Garry C. Myers, Jr., following graduate work at M.I.T., is Project Aerodynamicist in McDonnell Aircraft Corporation Helicopter Division.

Oran W. Nicks, former Oklahoma University Student, is Structural Engineer, North American Aviation, Inc.

Harold Oaklander is Development Engineer, Aerojet Engineering Corporation. He had been Assistant Superintendent of Stores, American Overseas Airlines.

Adolph Oltmann, formerly with Edo Corporation as Project Engineer, is now Design-Draftsman, Brookhaven National Laboratories.

Kenneth Paulovich resigned from Consolidated Vultee as Aerodynamicist to become Instructor, University of California.

Angelo J. Perna, former Senior Structures Engineer, Pilotless Plane Division, Fairchild Engine & Airplane Corporation, is in charge of Aircraft Engineering Program, Newark College of Engineering.

Richard J. Petrein resigned as Assistant in N.Y. University Department of Aeronautics to become Research Engineer, Standard Oil Development Company.

Robert E. Reedy is Assistant Chief Engineer, Radioplane Company.

Donald K. Robertson, former Vibration Engineer, has been promoted by The Glenn L. Martin Company to Senior Vibration Engineer.

Joseph P. Ryan is Acting Manager—Publications, Institute of the Aeronautical Sciences, Inc.

Silvio Roland Sartore resigned from Curtiss-Wright, Project Engineering, to become Engineering Specialist, McDonnell Aircraft Corporation.

Charles N. Scott is Research Engineer, Goodyear Aircraft Corporation. He had been with Consolidated Vultee Aircraft in the same capacity.

Manuel Silos, Jr., resigned from Engineering Service, Inc., to become Designer, Ford Motor Company.

James V. Smith has been named West Coast Representative of Stratos Corporation, in which company he had been Technical Service Engineer.

Sam S. Spektor is President, Spektor Production Engineering Company. He formerly was Plant Manager, U.S. Gas Range Corporation.

Edward N. Stevenson, Jr., former Structures Engineer with Bell Aircraft, now is Instructor, Aeronautical Engineering, West Virginia University.

Wilfred H. Stuth resigned from McDonnell Aircraft as Engineer to join the staff of the Southern California Cooperative Wind Tunnel.

Lowell Tellerman is Senior Designer "A," North American Aviation, Inc. He had been with Republic Aviation as Draftsman.

Neville A. Townsend was named Senior Structural Engineer, de Havilland Aircraft Company Ltd. He had been Assistant Chief Technician, Portsmouth Aviation Ltd., England.

Bernard Wallach, former Assistant Project Engineer, Sperry Gyroscope, is Development Engineer, Servo Corporation of America.

Joseph G. Walsh resigned from the David Taylor Model Basin, Navy Department, to become Engineer (Aerodynamics) P-1, Aerodynamics Section, National Bureau of Standards.

Stanley I. Weiss is Instructor, Department Theoretical & Applied Mechanics, University of Illinois.

B. Furman Wilkes is Instructor, Aeronautical Engineering, Aeronautical Industries Technical Institute. He had been with Shell Development Company as Junior Research Engineer.

Anthony V. Tuccillo has been promoted to Field Service Engineer, Piasecki Helicopter Corporation. He formerly was Layout Draftsman.

George H. Tweney is Associate Professor of Aeronautical Engineering, Department of Aeronautical Engineering, Wayne University.

Harry C. Zeislof, formerly with Aeronca Aircraft as Research Engineer, has been Appointed Development Engineer with Bendix Products Division, Bendix Aviation Corporation.

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Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Goldstein, Sydney, Ph.D., Beyer Prof. of Applied Mathematics, University of Manchester (England).

Hohenemser, Kurt H., Dr. of M.E., Chief of Aerodynamics, McDonnell Aircraft Corp.

Thomas, Henry Charles Baden, O.B.E., B.Sc., Sr. Principal Scientific Officer & Asst. Director/RDS, Ministry of Supply (England).

Transferred to Associate Fellow Grade

Fraser, Andrew Wauchope, Section Leader in Design Office, Scottish Aviation Ltd. (Scotland).

Scoles, Albert Buddy, M.S. in Ae.E., Director of Technical Liaison, Pilotless Plane Div., Fairchild Engine & Airplane Corp.

Sherby, Sydney Samuel, M.S. in Ae.E., Comdr.—Director, Test Pilot-Training Div., N.A.T.C. (Patuxent River, Md.).

Elected to MEMBER Grade

Bartlett, Theodore L., LLB, Coordinator of Aviation Activities, Radio Corp. of America.

Beck, Edgar Bertram, B.Ae.E., Research Asst., Polytechnic Institute of Brooklyn.

Bogdanoff, David, B.S. in M.E., Sr. Stress Analyst, The Glenn L. Martin Co.

Bowen, Kenneth P., B.S., Asst. Gen. Mgr., Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Boyer, Herbert, B.Ae.E., Aero. Engineer, Edo Corp.

Crane, Robert Miller, M.S., Aero. Research Scientist V, Ames Aero. Lab., N.A.C.A.

Denicke, Bert Anthony, Tech. Asst. to Director, Airway Operations Service, C.A.A.

Harrod, Harvey Theodore, B.S. in E.E., Mgr., Aviation & Ordnance Div., Westinghouse Electric Corp.

Kent, Robert Harrington, M.A., Associate Director, Ordnance Dept., Ballistic Research Lab. (Aberdeen Proving Ground).

LaBombard, Emerson Hogue, B.S. in M.E., Engineering Designer, Structures Group, Douglas Aircraft Co., Inc.

LaVier, Hurlbut William Smith, M.S. in Ae.E., Research Asst. Prof. & Project Director, Georgia School of Technology.

Ljungstrom, Olle, Ae.E., Structures Research Engineer, Saab Aircraft Co. (Sweden).

Nelson, Howard John, Jr., M.S.E., Sr. Aerodynamicist, Continental Aviation & Engineering Corp.

Oblinger, Richard Lee, B.S. in M.E., Field Engineer, Aero Engineering, Inc.

Rodney, George A., B.S., Test Pilot, The Glenn L. Martin Co.

Rogalski, S. W., Dipl. of M.E., Chief of Technical Dept., T.H.K. Airplane Factory (Turkey).

Rutkowski, Joseph, Ae.E., Supervisor in Aerodynamics, Dept. of Aero. Engineering, Lecturer, Aero. Research Center, University of Mich.

Ryan, William R., M.E., Director of Engineering, Edo Corp.

Savitsky, Daniel, B.C.E., Research Engineer, Experimental Towing Tank, Stevens Institute of Technology.

Spalding, Thomas Robert, B.S. in E.E., General Sales Mgr., Aviation Dept., Jack & Heintz Precision Industries, Inc.

Tibbs, Orville E., Director of Flight Test & Chief Test Pilot, The Glenn L. Martin Co.

Tucker, Alfred W., B.S. in Ae.E., Structural Design Engineer, Airplane Div., Curtiss-Wright Corp.

Wachtmeister, Carl-Gustav, Civilingenjor, Research Aerodynamicist, Saab Aircraft Co. (Sweden).

Young, George, B.Sc. in M.E. and E.E., Sr. Layout Draughtsman & Stressman, Scottish Aviation Ltd. (Scotland).

Zeerip, Thomas E., B.S. in M.E., Exec. Engineer, Head of Design & Development, Doman-Frasier Helicopters, Inc.

Transferred to MEMBER Grade

Cecka, William Joseph, Jr., B.Ae.E., Supervisor—Operations Unit of Propulsion Test Group, North American Aviation, Inc.

Cherne, Jack M., Sr. Structures Engineer, Sikorsky Aircraft Div., United Aircraft Corp.

Clarkson, Mark Hall, M.A., Research Engineer, Aerodynamics, Defense Research Lab., The University of Texas.

Crisman, Ronal B., B.S. in M.E., Associate Research Aero. Engineer, Composite Design Section, Cornell Aero. Lab.

Edelstein, Murray Irving, B.Ae.E., Research Engineer, Curtiss-Wright Corp. (Columbus).

Engelman, Thomas Urban, A.A. in Ae.E., Director of Public Relations, Grand Central Airport Co.

Majeske, Leonard Michael, B.Ae.E., Research Coordinator, Aircraft Materials, N.A.C.A. (Washington).

Saks, Robert, B.S. in Ae.E., Engineering Designer, Douglas Aircraft Co., Inc. (Santa Monica Div.).

Tomren, Raymond Henry, B.Ae.E., Research Analyst A, Engineering Dept., Northrop Aircraft, Inc.

Elected to Associate Member Grade

Brown, Gerald Daniel, Operations Supt., Flight Research Dept., Sperry Gyroscope Co.

Casamassa, Jack V., Sr. Instructor, Engine Dept., Academy of Aeronautics, Inc.

Kavanaugh, Paul, Tech. Translator, Chief, Aerodynamics Unit, Air Documents Div., War Dept.—Intelligence (Wright Field).

Pell, Clarence C., Jr., B.S., Chief, Air Transport Section, Engineering Dept., Aero Insurance Underwriters.

Smith, Gentry Burnette, Flight Inspection Foreman, Republic Aviation Corp.

Elected to Technical Member Grade

Freire, Luis Eduardo, M.S. in Ae.E., Lt. (SG), Maintenance Officer, Argentine Naval Air Force.

Kent, Sidney L., B.A.Sc., Taking Airline Serv. Mech. Course, Spartan School of Aeronautics.

Nicolaides, John Dudley, B.A., Aerodynamic Project Engineer, General Electric Co.

Paskus, Edward John, B.S. in Ae.E., Aeronautical Engineer P-2, U.S. Navy.

Snyder, Philip Stewart, Engineering Draftsman, North American Aviation, Inc.

Steinberg, Seymour, B.Ae.E., Aero. Engineer, Research on High Speed Propellers, Langley Mem. Aero. Lab., N.A.C.A.

Vincent, Kenneth Richard, M.S., Aero. Engineer P-2, Flight Propulsion Research Lab., N.A.C.A.

Wiggins, Roy Edward, Engineering Technician, Lockheed Aircraft Corp.

Transferred from Student to Technical Member

Armstrong, Gene Lee, B.S., Graduate Student, University of Illinois.

Baker, Elisha Remington, Jr., B.S.Ae., Flight-Test Engineer, A.M.C., Wright-Patterson Air Force Base (Wright Field).

Boone, Charles Guthrie, B.Sc. in Ae.E., Analytical Engineer (Jr.), Pratt & Whitney Aircraft Div., United Aircraft Corp.

Borgstrom, Thomas John, B.S. in Ae.E., Performance Engineer, A.M.C., Wright-Patterson Air Force Base (Wright Field).

Brown, Charles Eldridge, B.S., Administrative Asst.—Trainee, Parker & Co.

Cadwell, Joseph Daniel, B.S. in Ae.E., Research Engineer, United Aircraft Corp.

Canning, Glenn Donald, B.S. Air Transportation, First Officer, T.W.A.

Cherry, Robert Luther, B.S. in Ae.E.

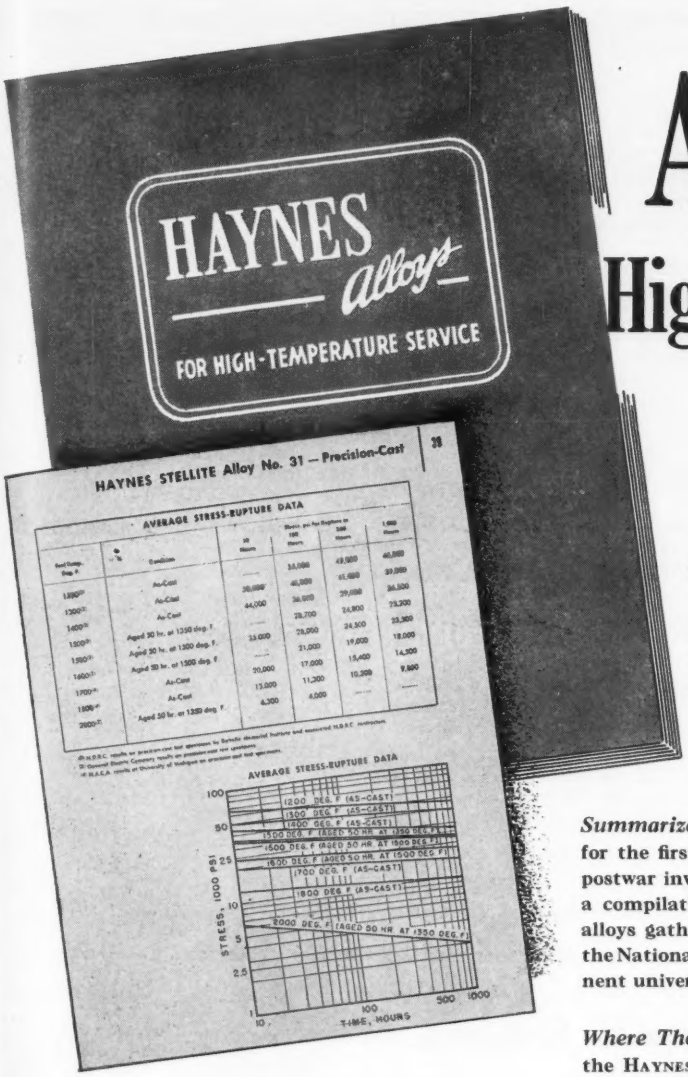
Clinton, Robert L., B.S., Draftsman, Consolidated Vultee Aircraft Corp.

Coletta, Arthur Pasquale, Student, Polytechnic Institute of Brooklyn.

Collier, Thomas Clayton, Jr., B.S., Salesman Trainee, Indland Container Corp.

Dolan, Thomas E., B.S. in Ae.E., Production Liaison Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Douglass, David R., B.S. in Ae.E., Instructor, University of Washington.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Eastman, Douglas E., Jr., Student, Academy of Aeronautics.

Forshee, William A., B.S. in Air Transportation, Asst. Airport Mgr., City of Hawthorne.

Glenn, Marvin Melvin.

Gregg, Arthur Busby, Jr., B.Ae.E., Development Engineer, General Electric Co.

Goodrich, James Frederick, B.S. in Ae.E., Flight Test Data Analyst, McDonnell Aircraft Corp.

Hartley, Richard Marshall, B.S., Jr. Professional Asst. Aero. Engineer, David Taylor Model Basin, Navy Dept.

Hedgepeth, John Mills, B.Sc. in Ae.E., Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Higbee, William W., Ae.E., Capt.—Meterologist, U.S.A.F.

Hirsch, Harold D., B.Ae.E., Engineering Technician, Lockheed Aircraft Corp.

Houseworth, William Harry, B.S., Aero. Engineer P-1, Flight Propulsion Research Lab., N.A.C.A.

Joseph, Donald Marvin, B.S., Jr. Engineer, Packard Motor Car Co.

Koch, Neil George, B.S., Designer-Draftsman, Chevrolet Motor Div., General Motors Corp.

Kopchinski, Norbert L., Jr., Tool Engineer, Grumman Aircraft Engineering Corp.

Loveman, Kenneth J., B.Ae.E., Jr. Test Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Markus, Eugene, B.Sc., Jr. Engineer (Aircraft Wheels & Brakes), Bendix Aviation Corp.

Marx, Michael Ferdinand, B.Ae.E., Instructor, Aeronautical Engineering, Rensselaer Polytechnic Institute.

Mautner, Richard Curtis, B.S. in M.E., Jr. Engineer, Johnson Outboard Motors.

Micks, William Raymond, M.S., Aerodynamicist, Douglas Aircraft Co., Inc.

Murray, Emory Fisher, B.S. in Ae.E.

Needham, James Fred, B.S. in M.E., Mathematician (Stress Dept.), Douglas Aircraft Co., Inc.

Novak, Stanley L., B.S. in Ae.E., Engineer—Aerodynamics Dept., Chase Aircraft Co., Inc.

Pahnke, Eugene Robert, B.S. in Ae.E., Engineering Technician, Lockheed Aircraft Corp.

Perry, Edwin Broyles, B.S., Aero. Engineer, Consolidated Vultee Aircraft Corp.

Pope, George Ralph, B.S. in M.E., Engineer (Design & Layout), Hamilton Standard Propellers Div., United Aircraft Corp.

Post, Jack Emmerson, B.S., Draftsman, Babcock & Wilcox Co.

Prodan, John, B.S., Research Engineer, United Aircraft Corp.

Quinlivan, William Joseph, Draftsman, G. M. Giannini & Co., Inc.

Raiford, Joanna, Miss, B.Ae.E., Aerodynamicist, Piasecki Helicopter Corp.

Reed, Verlin Dean, B.S. in Ae.E., Aero. Engineer, Ames Aero. Lab., N.A.C.A.

Rosenberg, Murray Arthur, Design Draftsman, Chase Aircraft Co., Inc.

Sabatiuk, Andrew, B.Ae.E., Research Project Engineer, United Aircraft Corp.

Sagata, Juro, B.S. in Ae.E., Structures Design, Douglas Aircraft Co., Inc.

Scott, Harry J., Jr., B.S.E. (Ae.E.), Aero. Engineer, Stalker Development Co.

Sellers, John Paul, Jr., B.M.E., Research Associate, The Ohio State University Research Foundation.

Sherman, Anson George, B.S., Products Engineer (Trainee), United States Rubber Co.

Shutte, Robert Henry, B.S.E. (Ae.), Mathematician A., Consolidated Vultee Aircraft Corp.

Sinclair, Archibald Robins, B.S. in Ae.E., Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Stillman, William Parish, M.S. (Aero.), Jr. Aerodynamicist, University of Chicago.

Wagner, Charles Henry.

I.A.S. National Meeting Schedule

Annual Summer Meeting—Hotel Ambassador, Los Angeles—July 14–16

Wright Brother Lecture—Washington, D.C.—December 17, 1948

Seventeenth Annual Meeting—Hotel Astor, New York, N.Y.—January 24–27, 1949

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review.*

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Personnel Opportunities

This Section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

WANTED

Aerodynamicists—The University of Michigan Aeronautical Research Center at Willow Run Airport, Ypsilanti, Mich., has several openings on its research staff for aerodynamicists with experience in theoretical supersonic aerodynamics for work with supersonic missiles. Positions require good academic background and sound knowledge of dynamics and applied mathematics. Advanced degree desirable. Applicants are invited to send a complete outline of their academic qualifications and experience to the Personnel Office, University of Michigan, 208 University Hall, Ann Arbor, Mich.

Mathematician—The University of Michigan Aeronautical Research Center at Willow Run Airport, Ypsilanti, Mich., has an opening on its research staff for a mathematician with some familiarity with problems of rocket flight and analysis of trajectories. Advanced degree essential. Applicants are invited to send a complete outline of qualifications and experience to the Personnel Office, University of Michigan, 208 University Hall, Ann Arbor, Mich.

Aerodynamicists and Aeronautical Engineers—Positions available for highly qualified technical personnel with good theoretical or experimental background to engage in development of facilities and model test work in stability, control, high-speed, and supersonic aerodynamics. Projects include new models of piloted and pilotless aircraft, new wind tunnels and associated equipment, and advanced testing techniques. Salary in accordance with qualifications and Civil Service regulations. In reply, please give brief summary of personal qualifications, education, and experience. Address—Director, David Taylor Model Basin, Washington 7, D.C.

Professor—The College of Engineering, West Virginia University, has an opening for a Professor of Aeronautical Engineering and Head of Department. The salary for a properly qualified man is $6,000. Interested parties may contact R. P. Davis, Acting Dean, College of Engineering, West Virginia University, Morgantown, W.Va.

Flutter Engineer—Aeronautical Engineering graduate with several years of experience in flutter and vibration problems needed for work on advanced military aircraft. Address reply to Engineering Personnel Office, North American Aviation, Inc., Municipal Airport, Los Angeles, Calif.

Electrical and Electronic Engineers—Graduate electrical engineers, 3 to 5 years' experience in design and development work. Must be qualified to do original circuit design work. Experience in electronic computer design desirable. Write Personnel Manager, Link Aviation, Binghamton, N.Y. Interviews will be arranged.

Instructor—Engineer—The Test Pilot Training Division of the Naval Air Test Center, Patuxent River, Md., requires two aeronautical engineers to instruct student test pilots in aeronautical engineering fundamentals and test procedures and to act as a test-methods development group. Ratings offered Aero-Engineer (Aerodynamics) P-5 or P-6 at $5,905.20 to $7,102.20 per annum and Aero-Engineer (Power Plants) P-4 or P-5 at $4,902.00 to $5,905.20 per annum. Experience in testing, teaching, or experimental work required. Address replies to Director, Test Pilot Training Division, Naval Air Test Center, Patuxent River, Md. Civil Service Application Form 57 may be included.

Aeronautical Engineer (General)—The U.S. Naval Air Station, Quonset Point, R.I., has vacancies for Aeronautical Engineer (General) P-5, $5,905.20 a year. Qualifications—In addition to a degree in engineering or 4 years of successful progressive technical engineering experience, applicants must have had at least 4 years of progressive professional engineering experience. Duties—Directs and supervises an Aeronautical Engineering Section in the overhaul and repair of all types of aircraft components. Responsible for the design of aircraft parts and assemblies and for the correct and accurate preparation of sketches and drawings. Applicants should file Standard Form 57 (obtainable at any First or Second Class Post Office) with the Recorder, Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I.

Aeronautical Engineer (Power Plants)—The U.S. Naval Air Station, Quonset Point, R.I., has vacancies for Aeronautical Engineer (Power Plants) P-3, $4,149.60 a year. Qualifications—In addition to a degree in engineering or 4 years' successful and progressive technical engineering experience, applicants must have had at least 2 years of professional engineering experience. Duties—Responsible to investigate and make recommendations for action on engineering requests from the Engine Overhaul Division of the Assembly and Repair Department. Prepares smooth drafts of local engineering specifications, engineering instructions, drawings, sketches, and other technical data and reports. Applicants should file Standard Form 57 (obtainable at any First or Second Class Post Office) with the Recorder, Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I.

Engineering Draftsman (Aeronautical)—The U.S. Naval Air Station, Quonset Point, R.I., has vacancies for Engineering Draftsman (Aeronautical) SP-5, $2,394.00 a year. Qualifications—Three years' total drafting experience, which must have included 9 months of specialized experience in the aeronautical field of drafting; or 3 years or more of college or university study in architecture or aeronautical engineering may be substituted for the experience required above. Duties—Prepares sketches, designs, and drawings for the repair, installation, or modification of aeronautical fixed equipment, allied components, and airframe assemblies and structures in connection with the modification, overhaul, and repair of aircraft. Applicants should file Standard Form 57 (obtainable at any First or Second Class Post Office) with the Recorder, Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I.

Flight-Test Engineer—Flight-test program for the development of automatic flight controls requires engineer to assist on project work. Work includes planning of installations of test equipment and electrical recording gear and its operation in flight. Applicant should be familiar with aircraft operations and possess a background in aeronautical or mechanical engineering plus some knowledge of electrical equipment and dynamics. Address replies to Mr. A. F. Coleman, Instrumentation Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

Professor or Instructors—Salaries comparable to industrial salaries. Opportunities for research and writing. Excellent facilities. Fields: engineering, transportation, and operations. Address: Director, University of Southern California, College of Aeronautics, Santa Maria, Calif.

849. Mechanical Designer—Small organization requires engineer to take charge of mechanical design activities. Familiarity with aircraft requisites highly desirable. This is an excellent opportunity for the properly qualified man who is able to accept responsibility. Give full details of education, experience, and salary expected.

848. Analytic and Design Engineer—Small New England organization building complete aircraft requires a versatile graduate engineer. Must be capable of accepting responsibility in design and in the preparation of analytic and stress analysis reports. Knowledge of aerodynamics, vibration, and testing procedure highly desirable, particularly rotary wing. This position offers a unique opportunity for the properly qualified engineer. Give full details of education, experience, and salary expected.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

AVAILABLE

875. Production Liaison Engineer—B.A.E., 1941. Familiar with aircraft design, stress, research problems, and fabrication methods, factory and field. Familiar with organizational setups, systems of control for management. Broad engineering background, education, with emphasis on production and production management. Proved capable of assuming and delegating responsibility, coordinating activities of groups at various levels. Sales-minded; works well with others. Currently employed. Desires position on production staff of manufacturing organization.

874. Power Plant Engineer—Thermodynamicist—Thoroughly experienced in power-plant installation thermodynamics, reciprocating and jet engines, after-burning, cycle analysis, compressible flow, air conditioning, pressurization, fuel, lubrication systems, engine and tailpipe cooling, supersonic wind-tunnel design. Available on permanent or consulting basis.

872. Technical School Executive.—Sixteen years' executive, administrative, and teaching experience in North and South America. B.S. Degree in Mechanical Engineering. Working knowledge of all phases of school operation. Desires managerial position in private, Government, or company-operated technical training program. Aviation activity preferred.

871. Sales-Survey-Management Engineer—B.S. in Business and Engineering Administration, M.I.T.; 3 years' aeronautical engineering; 1½ years' engineering administration. Recent experience in aircraft export sales management including foreign contacts. Also some business survey and analysis background. Commercial pilot with civilian instructor rating; military multiengined experience. Married, age 26. Any location (including foreign) considered seriously.

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869. Engineer—B.S. in E.E., M.S. in Ae.E. Four and one-half years' experience in development, test, and manufacturing of automatic flight control systems for conventional aircraft and guided missiles. Desires position in New York City area.

868. Management or Administration—A.B. degree, University of Pennsylvania; 28 years old; single. Major in political administration, courses applicable to business administration. Courses in industrial engineering including industrial relations, business and Government, organization and organizational structure. Aeronautical engineering courses in elementary aerodynamics, performance calculation, aircraft drafting, and engineering. Over 4 years in aircraft testing in present position. Desires permanent position on junior level in management or administration with opportunity for advancement. Philadelphia, Pa.

867. Washington Representative—B.S. in Aero. Engr., married, firmly established in Washington, available for full or part-time work as technical representative. Experience with U.S. Air Forces, Bureau of Aeronautics and N.A.C.A. in structures, materials, helicopters, and personal equipment. Familiar with the present research and development programs of the services on materials.

866. Layout Draftsman—Six years' experience in aircraft industry. Four years' experience on fuselage and electrical installation. Desires responsible layout position. Will locate in New Jersey or New York.

865. Structural Engineer—B.S. in M.E. Age 29; single. Eight years' experience in aircraft design with large concern. Five years in stress analysis, 2 years in static test, and 1 year in drafting. Mechanically inclined. Familiar with military and C.A.A. requirements. Will locate anywhere in U.S. Desires position utilizing experience and offering advancement.

864. Management Executive—B.S. in M.E. Over 20 years' experience in aviation, including engineering, production, quality control, contracts, contract termination, labor problems, materials, costs, and sales. Five years' research, N.A.C.A. hydrodynamics and aerodynamics. One year flight performance data analysis. A & E mechanic, private pilot. During war represented the Bureau of Aeronautics in plants of major aircraft manufacturers, heading staffs up to 160 engineering, clerical, and shop personnel. Present position: directing rocket and air engine test and development at Navy test center. Long experience in dealing with Government agencies. Desires responsible position with an organization needing a versatile, well-informed executive.

863. Research Administrator—Six years' industrial design, 8 years' chief research engineer large corporation, 3 years' professor and consultant for large engine builder, 8 years' director of university aeronautical research laboratory, 14 years' part-time teaching. One hundred and fifty patents. Specialized in power-plant, Government, and industrial contracts. Age 53. Broad experience. A-1 references.

862. Engineer—Graduate (majors in Physics and Mathematics) of University of California. One years' graduate work in Physics. Five years' experience as a stress analyst and dynamicist in aeronautical engineering. Position preferred in Los Angeles area.

861. Physicist-Aerodynamicist—Age 42. B.S. degree in Physics and Mathematics and 1 year graduate study in physics. Professor of Aeronautical Engineering with administrative experience and 12 years of nationally recognized work as research physicist with the N.A.C.A. Desires responsible position teaching aerodynamics, theo-

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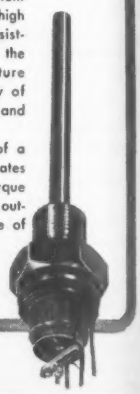

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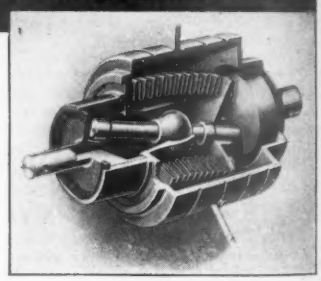

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860. Aeronautical Engineer and Thermodynamicist—B.Ae.E., Rensselaer Polytechnic Institute, 1940. One year's experience as junior engineer at N.A.C.A. Six and one-half years' experience with aircraft manufacturer and present employer. Four years' in aerodynamics department doing general performance work and specializing in engine cooling, cowling, ducting, heat exchange and all internal flow on aircraft for reciprocating and turbojet engines. The past 2½ years spent as head of engine research group conducting compressible flow analyses in connection with current active missile designs. Specialized in supersonic diffusers and in ram-jet engine performance. Familiar with turbojets, pulse-jets, and present-day rockets. Desires position dealing with research on ram-jets, diffusers, supersonic wind tunnels, general flow problems, or any active engine program for use on missiles. Organization or university should have a sound and stable outlook for future work in the research field. Desirable to have facilities available for continuance of education.

859. Experimental or Inspection—Twenty years' aircraft experience. Seeks supervisory position.

858. Service Engineer—Engineering training and background; A & E license. Considerable experience as company representative on Navy experimental airplanes. Experienced in investigating service troubles and writing service bulletins to cover same; compiling technical manuals.

857. Aeronautical Engineer—Teacher, with 7 years of experience in the aircraft industry and the aeronautical teaching field, is looking for a new connection either in teaching or in industry. Aircraft industrial experience includes administration of engineering programs resulting in C.A.A. type approval along with the necessary personal contact work. Complete knowledge of the civil air regulations gained through several years with the C.A.A. Experience in design and stress analysis includes considerable work in rotating wing aircraft, as well as general aircraft design. Non-aircraft experience includes work in optics and refrigerating unit design. Teaching experience includes presentation and development of courses in wind-tunnel operation, aerodynamics, high-speed aerodynamics, design, stress analysis, propeller design, and rotary wing aerodynamics. Author of several published papers in the fields of stress analysis and design. Education consists of Bachelor's and Master's degrees in Aeronautical Engineering from large Eastern university. Full details and a list of references will be supplied on request. Location open.

855. Aeronautical Engineer—Aero. E. from University of Cincinnati. Age 29; married. Limited experience in tool design, tool liaison engineering, and detail design. Five years' Army Ordnance experience in administration control, and teaching. Presently assigned as Ordnance Assistant Professor of Military Science and Tactics at a large Midwestern university. Interested in design engineering, liaison engineering, jet and supersonic research and teaching. Prefers Pacific Northwest but will consider West of Mississippi or South America. Available August 1, 1948, but requires immediate contact.

854. Engineer—For British commonwealth countries, engineer with 30 years' practical experience, 10 years' aeronautical, 10 mechanical, 5 electrical, and 5 marine, in all phases for original designing, shop detailing, prototype building, ground and flight testing, commercial production, sales, installation, and field service. Most suitable for foreign branch needing "one man show" to run it. Lengthiest experience is in engines, instruments, and accessories.

853. Aeronautical Engineer—Fifteen years' actively engaged in the aircraft industry, including project design, flight test, and development engineering, and as representative in procurement and service. Thorough knowledge of layout and design plus 7 years' experience on individual projects, from preliminary design through to flight test and field service. Four years' university work and graduate of two leading schools of aeronautics. Instruction to flight personnel on maintenance and altitude operation. A & E licenses. Working knowledge of Spanish and French. Desires permanent responsible position and opportunity for advancement in design, development, service, or sales. Will consider preferred stock in lieu of portion of salary. Geographical location unimportant. Excellent commercial and military references.

852. Air Cargo Transport Engineer, Executive and Administrator—Available on short notice, internationally known air transportation engineer, specializing in air cargo. Just completed setting up largest private all-cargo operation in the Western Hemisphere. Capable of making complete survey, procuring equipment and personnel and setting up operating organization. Would be interested in acting as operations executive or consultant for any company anticipating aircraft operation or activity, or any organization interested in air cargo. Thirty years' experience in the aircraft operating and construction, maintenance fields. Has lived and operated in Europe and South America and has acted as consultant to U.S. Army Air Force.

851. Aeronautical Sales Engineer and Aeronautical Marketing Consultant—Exceptional aeronautical background and history. Entree to every phase of aircraft manufacture and operation. Internationally known and respected. Has excellent contacts, particularly on the Pacific Coast. Has designed and patented several successful accessories. Has been in the aircraft field for over 30 years.

850. Aeronautical Engineer—Age 26; B.S. in M.E. Will receive M.S. in A.E. (Jet Prop. Option) from California Institute of Technology in June, 1948. Experience includes one semester as instructor in mechanics, 2 years in aircraft research laboratory, and 2½ years as stress analyst on large military aircraft. Currently employed in GALCIT wind tunnel. Desires either academic or industrial position with good future.

847. Administrative Engineer—Age 26; S.B. aeronautical engineer, S.B. business and engineering administration, M.I.T. Five years' experience in operational and maintenance engineering with large international air line. Line station experience in Brazil. A & E license. Well qualified for analysis of operational problems involving cruise procedures, market analysis, scheduling, liaison between flight and ground personnel, standards. Desires work with either an aircraft manufacturer or operator.

846. Pilot Engineer—B.S. Aero. E., Iowa State College; age 24; married. Pilot—commercial airplane single- and multiengined land with instrument and flight instructor ratings. Sixteen hundred accident-free hours. Some sales experience. Interested in flying position with private concern or air line or in sales engineering. Wants permanent position and will locate anywhere.

845. Controls Engineer—B.S. in Ae.E., graduate study. Six years' design and supervisory experience with major air-frame and accessory manufacturers. Electronic experience in military service. Specialization—electrical and hydraulic equipment for operating power-plant controls, armament, landing gear, surface controls, and accessories. Some experience with automatic pilots, data transmission systems, and other forms of automatic controls. At present, installations engineer with accessory manufacturer. Location Midwest or West of Mississippi.

844. Director of Research—Holds B.E. M.S., Ph.D. degrees in Metallurgy and M.S. in Aeronautics (jet propulsion major). Eight years in industry and 2½ years in Navy and guided missile programs. Seeks executive position where organizational and administrative talents may be used.

Aeronautical Reviews

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gages were in circuit for only a few seconds to minimize the resistance variation of the gages with variations of current and time.

Thermodynamics (18)

Technical Thermodynamics of Dissociating Gas Mixtures. Otto Lutz. (*Luftfahrtforschungsanstalt Hermann Göring, Braunschweig, ZWB/LFA.*) *U.S., Air Force, Translation No. F-TS-997-RE,* January, 1948. 79 pp., figs. 13 references.

Graphical-mathematical methods for calculating the thermodynamic characteristics of dissociating gas mixtures. The tables for the mixture composition which are compiled give a synoptic view of the behavior of dissociating gas mixtures at temperatures up to 4,000°K. The data from these tables, when the heat of dissociation of the compounds is taken into account, permit the formal representation of the changes of state of the dissociating mixtures by stoichiometric diagrams. By these it is also possible to express clearly the effect of the flow of the dissociating gases. The method is applied to combustion phenomena in general, the thermodynamics of rockets, and the cycle efficiencies in combustion engines.

Wind Tunnels & Laboratories*

Research for Speed; Survey of Variable-Density High-Speed Tunnel at Royal Aircraft Establishment, Farnborough. *Flight,* Vol. 53, No. 2045, March 4, 1948, pp. 256–262, illus.

General description of the installation with cutaway drawing showing refrigeration and compressor-evacuator plant, the working section, fan unit, control unit, and motor room. Emphasis is placed on the refrigeration system, operating staff, and range of tunnel operation. Detail force diagrams show operation of the balance for each of the six components measured.

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● Helios† papers, cloths and films bring to the field of dry diazo reproduction the same dependability which has made other K&E "partners in creating" the preferred tools of engineers and draftsmen. You use Helios materials with complete confidence that you will get clear, easy-to-read prints every time.

Research and tests over a number of years showed only one way to insure that Helios materials would be a more *dependable* line of dry diazo materials than had ever been made before—and that was to have absolute control of the purity of all chemicals essential to the performance of Helios products.

The new K&E plant, pictured below, was established for the manufacture of Helios materials exclusively. We not only make the finished product—but we manufacture, to our own exacting standards, the required color-forming components. You see the results whenever you make prints on Helios papers, cloths or films—for their consistently high quality is due to the fact that, from start to finish, Helios materials are made with the skill, care and vigilance which have been characteristic of K&E throughout 81 years of making drafting and reproduction materials and equipment.

partners in creating

You can make positive line working prints on opaque Helios papers or cloth *directly* from original drawings, layouts, letters, documents, forms. Or you can save your originals and reproduce positive line working prints *directly* from positive line intermediate originals on Helios transparent papers, cloth or films. Write Keuffel & Esser Co., Hoboken, N. J. for samples, or ask your K & E Dealer or K&E Branch for a demonstration. Remember . . . you're *positive* with Helios!

K&E

Drafting, Reproduction, Surveying Equipment and Materials. Slide Rules, Measuring Tapes.

†Reg. U. S. Pat. Off.